

HERBAGE REVIEWS

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Articles.	Page.
The artificial drying of grass in Britain. E. J. Roberts	65—73
The foothills grazing problem in India. R. MacLagan Gorrie	74—8
Reviews.	
Roots of meadow plants in different habitats	79—82
The hormone theory of vernalization	83—6
Influence of external factors on seed-setting in lucerne	87—90
Nitrogen on seed plots of <i>Festuca rubra</i> and <i>Poa pratensis</i>	91—3
Methods for estimating yield of grassland	94—7
Grassland research in Kenya	98—101
Soil Conservation Service	102—5
Wind erosion in the Southern Great Plains	106—7
Measurement of xerophytism in selected pasture grasses	108—110
Annotations.	
Great Britain, Czechoslovakia, France	111—3
U.S.S.R., Sweden, Holland	113—6
U.S.S.R. (Siberia), Brazil	116—7
Conferences.	
Moscow, 1936	118—20
Index of Genera	iii—iv

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THE ARTIFICIAL DRYING OF GRASS IN BRITAIN.

E. J. ROBERTS.

INTRODUCTION.

THE Committee of the Agricultural Research Council on the Preservation of Grass and other Fodder Crops issued a report (1) on grass drying at the end of 1935, and, in continuation of that work, appointed me to make a survey of this new development in 1936. The results of this survey have been published recently (2); this paper summarizes portions of that report.

Grass drying in Britain denotes the artificial drying of young, leafy pasturage, an operation that made its entry into farm practice as recently as 1936. This development arose from the research work, at Cambridge, of Woodman and colleagues (3, 4, 5), who showed that the dry matter of young grass is similar in feeding value to a protein concentrate. Furthermore, it was shown that this high value is independent of the botanical composition of the herbage and that it can be maintained until the end of the season, provided the grass is kept short. Thus, it was pointed out (3) that the digestibility of the organic matter of grass cut at weekly intervals varied from 74.0 to 83.6, compared with 80.1 in linseed cake, 70.8 in palm kernel cake, and 81.7 in barley meal. When the intervals between mowing were extended to a month or five weeks, the reduction in feeding value was not serious; thus, in 1930, the proportion of crude protein in the dry matter of grass cut at intervals of a month did not fall below 17.2 per cent on any occasion, nor did the digestibility of the organic matter go below 76.7.

Research work on the conservation of such young, leafy herbage for winter feeding followed the discoveries noted above; it is obvious that in a country like Britain, which is so suitable for the production of high-quality grass, the possibility of producing concentrated balanced feeding stuffs from grassland is a consideration of the first importance. Conservation by curing in the field, in the usual way, is impracticable because, apart from other considerations, the handling and collection of the short herbage would involve too much loss and expense. Short grass may be preserved by ensiling, but, even with improved methods, it is difficult to avoid a loss of food value of less than 10 per cent, and to guarantee a highly palatable product. Experimental work on the artificial drying of young grass established the fact that it is possible to preserve pasturage in this way with practically no loss of feeding value (6, 7, 8, 9, 10, 11, 12, 13) or of palatability. Thus, Watson, having compared a sample of fresh grass with the dried grass prepared from it, found that the digestibilities of the fibre, crude protein and organic matter were 80.4, 77.6 and 77.3 respectively in the former, against 78.1, 72.6 and 75.7 in the latter. Furthermore, carotene, the parent substance of vitamin A, valued because of the rich colour that it imparts to milk and butter, is preserved without loss when grass is dried artificially.

DEVELOPMENT.

Artificial drying on a commercial scale in Britain began in 1933, when Messrs. British Crop Driers Ltd. set up in Norfolk, Ransome-Davies machines for drying the lucerne from 2,000 acres. By the beginning of the 1936 grass season, small grass driers, with a rated output of about three to four cwt. per hour and suitable for use on the farm, were available for purchase. During that season, the number of grass-drying centres rose from less than a dozen, including several of an experimental type, to nearly fifty; again, while only one make of farm drier was available in 1935, the number had risen to six by the end of 1936. The development of artificial drying in Britain is characterized by the use of the small unit, suitable for use on farms of average size, while abroad the small drier has not been developed. Again, nearly all the dried grass produced on farms is pressed, in the long state, into tight bales: most of it is fed to cattle, and it is more convenient to feed the material in this state than when it has been ground or chaffed. It should be mentioned that though all the driers, excepting two that operated in 1936, were of the farm size, the factory drier of Messrs. British Crop Driers Ltd. working without interruption throughout the season, was responsible for a third of the country's output.

THE PRODUCTION OF SUITABLE HERBAGE.

The artificial drying of green fodders for the purpose of producing feeding stuffs of high nutritive value may be carried out with pasture grass, lucerne, cereals, etc., provided the herbage is cut before it reaches that stage of maturity when the proportion of protein begins to fall, the fibre to increase, and the digestibility to decrease. Pasture grass should be mowed before it reaches the stemmy condition, if the highest quality of product is desired, and, in the management of grassland for drying, this objective is kept continually in view. The production of suitable grass at a low cost is an important necessity in the development of grass drying. In the large amount of research work that has been carried out with herbage plants, many aspects have a direct bearing on important points connected with this new development, and the questions asked by producers relative to the production of young, leafy grass made it obvious that it was highly desirable that the literature on grassland research should be examined; fundamental and other work on grass had already supplied much of the information of the type sought by producers, and it seemed essential that this information should be collected for making it available.

The yielding capacity of pastures when cut at frequent intervals is of great importance. An examination of the results of British plot experiments (14, 15, 16, 17, 18, 19, 20), in which the pasture was mowed at intervals of four or five weeks, showed that the average yield, without manures, was about 38 cwt. per acre, and that this could be raised by manuring to 50 cwt. Actual yields of baled dried grass were obtained from a few centres; data are limited, because, in many instances, fields were not reserved exclusively for drying, but were grazed for a short period in addition, or a crop of hay was taken. The actual yields of baled dried grass varied from 40 to 80 cwt.; the number of fields of which yield data are available is insufficient to justify the use of an average figure for yield.

The yield of grass from a number of frequent cuts is not as high as when hay and aftermath only are taken. With the hay and aftermath, however, the food value per unit weight is considerably lower than that of the fodder obtained from frequent cuts, and there is probably but little difference in the total yield of nutrients from the two systems of mowing. There is not much evidence available regarding the effect of frequent mowing, for more than one season, on the productivity and botanical composition of the sward, but there is sufficient to show that pastures vary greatly in this respect; agricultural experience would lead one to expect that grassland in good heart would resist the effects of frequent cutting better than inferior

land. In some experiments, no harmful effects as a result of frequent mowing have been recorded, while, in others, plots have had to be discarded after two seasons of mowing because of the extent to which the sward had deteriorated.

The quality of dried grass at a given centre is influenced mostly by the length of the intervals between mowing. Manures have very little effect on the chemical composition of the herbage, though, in some soils a marked improvement in the mineral content of the herbage may result. The application of nitrogenous manures may result in a small increase in the proportion of crude protein. Thus Gardner (20) obtained the following results :

Table 1.—Percentage of crude protein in grasses and clovers.

	No nitrogen.	Manured with nitrogen.
Grasses	17.3	18.6
Clovers	26.4	26.9

Extensive experiments by Greenhill (19) show that the improvement in the proportion of crude protein is rarely likely to be anything but small.

GRASS DRYING MACHINES.

Grass driers sold in Britain may be classified as follows :— [A full description and illustration of each make has been given elsewhere (2).]

1. *Tray driers*. These are batch driers in which the grass is hand-shaken from one tray to another half-way through drying, in order to facilitate even drying.

(a) *Billingham drier*. Trays moved in and out of oven. The manufacturing costs of this drier are now too high for it to be marketed.

(b) *Curtis-Hatherop drier*. Trays stationary. Principle of re-circulation used.

2. *Endless belt driers*. The fresh grass is put in at one end, and emerges dry at the other without being handled during drying.

(a) *Ransome-Davies drier*. The simplest form of conveyor type drier. There are two temperature stages in order to secure lower temperature at outlet end. Re-circulation is adopted in the interests of fuel economy.

(b) *P and M drier*. Furnace gases penetrate grass mat from above and from below, according to its position as it travels along. There is a device for even spreading. Automatic stoker and temperature controls are fitted as standard.

(c) *Mobile drier*. Six super-posed conveyors with cascading effect from one to the other. Drying by radiant heat as well as by convection current. All models are portable.

3. *Revolving drum drier*. The revolving drum produces the effects of mechanical agitation while the herbage is in the drying current.

Kaloroil rotary drier. Two stage, continuous drier, the first stage of drying taking place in a hopper above the drum. Little or no expense required for foundations.

4. *Pneumatic*. The grass is dried as it is carried along in the drying current. A higher temperature is employed than in other driers, but the material is in contact with the hottest gases only for a short time.

Lister drier (Greenwell patent). After the grass has passed through the pneumatic stage, it is held in a drum until drying is complete. It is doubtful if this machine will be on the market in time to be used in 1937.

Temperatures of the drying current are mostly around 150°C. Experiments (21) have shown that the quality of the product is not affected by the drying temperature, provided the material is removed as soon as it is dry. With a high outlet temperature it is not easy to ensure that this is always done. Thus, Hodgson and

colleagues (22) in America found that, whereas there was no depression in the digestibility of young grass dried with outlet temperatures of 250°, 300° and 350°F. there was evidence of deterioration when the outlet temperature was 400°F. High outlet temperatures also increase the risk of fire, due to the possibility of a mechanical break-down resulting in failure to remove the whole of the dried product from the drying current.

Coke was used in nearly all farm driers in 1936, while the two factory driers operated on coal. The driers mentioned above are, with the exception of the Kaloroil, primarily designed for use with coke, but the furnaces are readily adapted to burn coal. The Kaloroil is supplied with an oil-fired furnace as standard, but may be used with either coke or coal. Oil is the most convenient form of fuel, requiring less attention, and being more convenient than coal or coke when shutting down for a meal, or for the night. Oil is, however, more expensive and, in spite of its convenience, is not used in Britain as widely as coal or coke.

It should be emphasized that it is important to secure the correct type of furnace, with efficient stoking, otherwise low outputs and high fuel costs result. One type of furnace supplied in 1936 was too small for the work expected of it, and, before the season was half-way through, most of these furnaces had to be re-lined. Not more than about 11 lb. of coke per hour should be burned per square foot of grate area. If it is assumed that from 5 to 7 lb. of water is evaporated by 1 lb. of coke, it is possible to calculate the correct size of furnace for a given amount of water to be evaporated per hour.

PERFORMANCE OF FARM DRIERS IN 1936.

Before discussing the performance of the farm grass driers, it may be well to consider what a good machine should do. A good drier should evaporate water efficiently, without causing deterioration in the product and, furthermore, it should do this at such a rate as to give a reasonable output, having regard to the requirements of the farm. The capital cost should be reasonable. It is difficult to stipulate definite figures in regard to the relationship between capital and output, but it may be stated with confidence that there would be a large demand for driers with an output (from fresh herbage of about 78 per cent moisture content) of 1 cwt. of dried grass per hour per £100 in capital expended on drier, furnace and motors. As regards fuel ratio, or the amount of water evaporated by a unit weight of the fuel, it is considered that a ratio of 1 : 7 is not likely to be exceeded in the small driers used on farms, that is, 7 lb. water evaporated by 1 lb. of coke.

(a) *Fuel ratio.* Evaporation tests were carried out in order to test the efficiency of the driers by determining the fuel ratio. An evaporation test is performed by weighing, over a given period, the fresh grass put into the drier, the dried grass produced from it, and the fuel consumed in the period, the difference between the weights of the fresh and dried grass gives the weight of water evaporated; such tests should be carried out over periods not shorter than one day in length. These tests can be carried out only at centres where facilities exist for weighing the fresh grass; facilities for weighing the dried grass and the fuel exist at most farms. The table below summarizes the results of the tests made in 1936. These results are not presented as criteria of efficiencies of the various kinds of driers, because the Billingham drier is no longer manufactured, and the other makes have been improved since the end of that season; the object of giving the results is rather to provide information that is necessary in forming an opinion on the first year of grass drying on the farm.

The results of these tests show that the fuel ratio of 1 : 7 was not attained during the season in any of the driers subjected to this test, and, secondly, that ratios as low as 1 : 3.5 were obtained under certain conditions, such as when shutting down for meals.

Table 2.—Summary of Evaporation Tests with small Farm Driers in 1936.

Centre	Duration of test.	Water evaporated by 1 cwt. coke. In cwt.	Units of electricity, for drying and baling, per ton of water evaporated.	Remarks.
1	Aug. 4 to Sept. 30	5.2	20	Ransome-Davies
1	Oct. 1 to Nov. 4	4.5	20	Same drier.
2	Sept. 8 to 15	5.5	54	Billingham.
2	One day	5.3	40	Same drier.
3	One day	5.8	Power supplied by tractor.	Small Curtis- Hatherop (flying start)
4	Two days	3.6	46	Stops for meals
5	Five hours	3.5	Not recorded.	Billingham.
6	Seven hours	1 gallon oil evaporated 96 lb. water.	33	Kaloroil
7	One day	1 gallon oil evaporated 84 lb. water.	15	Converted hop kiln.

(b) *Output.* The output of dried grass per hour is a very important consideration, apart from questions of efficiency and costs. Thus, in 1936, the fact that through-puts were lower than was anticipated had an important indirect effect on the quality of the product. The areas allocated for the driers were too large, so that the grass was too mature when it was cut; it is unlikely that more than 25 to 30 per cent of last year's production was mowed when in the leafy stage. The table below shows some actual average outputs per hour at some centres in 1936.

Table 3.—Average outputs of dried grass per hour, for the season.

Farm.	Average output of dried grass in cwt. per hour.	Total output for season.		Remarks.
		Tons	cwt.	
1	2.20	64	10	
2	2.41	99	3	
3	1.61	23	14	Aug. 24 to Sept. 30
4	2.13	28	6	Oct. 1 to Nov. 4.
5	2.25	329	4	Day and night shifts.
6	2.68	320	0	
7	1.31	287	0	
8	1.50	50	0	
9	2.55	61	2	
10	2.00	156	0	

These outputs are considerably lower than was expected. The low through-puts of farm driers was the most disappointing feature of the season's drying; the weight of dried grass produced per day was far too low, having regard to the size of the farm and to the capital necessary for purchasing the drier and equipment. The amount of capital corresponded to £130 to £350 per one cwt. an hour output, exclusive of field equipment. There are prospects of improvement in the capacity of farm driers in the 1937 season.

An imperfect picture of the performance of the small farm driers would be obtained if the results shown in the above table were not considered in relation to the moisture content of the fresh herbage. It was impossible to determine the actual quantities of water evaporated per hour over the season at the above centres, but, from determinations carried out at a few centres where weigh-bridges were available, it seems probable that each cwt. of dried grass in the above table corresponds to an evaporation of about 4 cwt. of water. Much more satisfactory outputs would have been obtained under conditions resulting in herbage containing less water. A small difference in the percentage of moisture makes a great difference to the amount of water that has to be evaporated in producing a given weight of dry product. Producers of dried grass use the term water-ratio, which signifies the ratio of the weight of dried grass to the weight of water evaporated in producing it; the latter is obtained by deducting the weight of dried grass from the weight of fresh herbage. The table below shows water-ratios corresponding to different moisture contents.

Table 4.—Percentage moisture, and corresponding water-ratios.

Moisture content of fresh herbage (in per cent).	Water-ratio.
90	9.0
85	5.6
80	4.0
75	3.0
70	2.3
65	1.9
60	1.5
50	1.0

Thus, from fresh grass containing 80 per cent of moisture, one ton more water would have to be evaporated than from herbage of 75 per cent moisture content, in order to produce one ton of dried grass. In discussing recently the results of an official test carried out abroad on a foreign drier, the cost of fuel per ton of the dried product appeared to be very much lower in the foreign than in the British farm driers. On a more detailed examination of the results however, the weights of fresh and of dried herbage in the test showed that the water ratio was only 1.75 in the test; the amount of water that had to be evaporated to produce one ton of dried material was thus about two tons less than under average British conditions in 1936. It may be said that, although the conditions in Britain appear favourable for the development of grass drying in so far as the production of good quality grass is concerned, the high moisture content of the herbage adds to the expense of drying and decreases through-puts.

Partial field drying or wilting may be practised in some instances in order to reduce the water content of the grass; the herbage is allowed to remain in the field for some hours before being hauled to the drier. If the grass is short, as it should be for the production of a good quality product, partial field drying has the disadvantage that it adds to the expense of collection. No implement is yet available that enables

short grass to be collected mechanically off the ground in one operation ; thus, the costs of cutting and collecting are higher than when using the Cutlift combine, which, in one operation, cuts and elevates the short grass to a trailer. Partial field drying results in a loss of carotene, a consideration that is sufficient to rule out this practice when the product is required for certain purposes.

COSTS.

In the course of the survey an opportunity was presented of obtaining costs accounts from twelve farms. Certain items in the costs, namely, wages, coke, electricity, tractor fuel, and baler bands, can be given with precision, but, with other items, such as manures, rent, and depreciation, considerable difference of opinion exists as to the best method of calculating these. The average cost of producing one ton of dried grass at the twelve centres is given in Table 5.

Table 5.—Cost of production of one ton of dried grass.

	£ s. d.	Percentage of total cost.
Wages	1 19 0	33.3
Coke	1 4 3	20.5
Electricity, or oil fuel	8 10	7.6
Tractor fuel, or horse labour	3 11	3.3
Baler banding	3 10	3.2
Manures	11 9	10.0
Rent	9 9	8.3
Depreciation	16 1	13.8
Total	5 17 5	100.0

The total cost is almost the same as that found by Dixey and Askew (24).

PROFITABLENESS.

If dried grass of good quality is valued according to the conventional method, the value per ton is about £6 15s od. ; this takes no account of additional value due to carotene. Prices realized for the product ranged up to £11 a ton, and most of the sales were from £7 to £8 a ton. It can be stated that, in 1936, the first year of this development on the farms of this country, the product was produced at a profit, though perhaps only a moderate one having regard to the capital and time that was necessary. The general average of quality throughout the country was not good, but as stated above, the herbage at certain periods grew so quickly that the driers could not cope with it. Thus, at one farm, the percentage of crude protein (dry matter basis) in 27 samples varied from 10.2 to 20.5 ; in another, the crude protein in 34 samples ranged from 7.3 to 16.5. These differ greatly from those envisaged by Woodman and Norman, (23) who, with monthly and five-weekly cuts in 1929, 1930 and 1931 obtained values of crude protein ranging from 14.1 to 25.9. It is difficult to estimate the effect on last year's profits of producing dried grass of a value lower than was originally anticipated ; it is possible that the effects may be felt more on the selling prices in the future. It is obvious that, since the cost of processing herbage is the same, whether or not it is of high value, the profitableness of grass drying will depend greatly on the management of the sward, particularly in regard to cutting the herbage at the correct stage of growth.

The advisability of embarking on grass drying cannot be decided merely by consideration of production costs and selling value. The alternative methods of utilizing grassland, grazing and haying, must be considered and compared with grass drying in regard to profits, capital necessary, etc. A comparison with grazing would not perhaps interest the average farmer, who would regard grass drying, not as an alternative to grazing, but as being complementary to it; it is a method of enabling most types of farm animals to be supported throughout the year on the produce of grassland only. Compared with haymaking, a calculation of production costs and food values shows that, if allowance is made for the cost of baling dried grass, it leaves a surplus of profit almost equal to that of medium quality hay, but about ten shillings per ton below that obtained from the best meadow hay. If allowance were made for the value of carotene, the comparative profitableness of dried grass appears in a more favourable light. However, it can be said that, even making no allowances for carotene, grass drying does not appear at such a disadvantage in the above comparison. With haymaking, however, the capital required is less, and, in addition it fits better into the farm routine, falling between sowing and the corn harvest.

The future of grass drying is also bound up with factors that do not enter into a profit and loss account. The Cambridge experiments, which included digestibility trials, indicate that the high nutritive value of young grass is maintained into the autumn, and, if this view is upheld in practice, this new development will have a powerful additional asset in its favour. Practical men, however, insist that, protein or no protein, summer and autumn grass does not give the same results as spring grass in milk production or in fattening. Research at the Hannah Dairy Research Institute (13) indicates that the efficiency of the proteins in autumn grass is not equal to that in spring grass; it should, however, be pointed out that even in autumn grass the proteins were found to be superior for milk production to those in linseed cake.

Finally, it is possible that the effect of dried grass on the health of animals may weigh considerably in its favour. Little definite information is yet available on this point, but there are indications that dried grass has a definitely beneficial effect on the health of dairy herds. After the winter of 1936-37, for instance, the owners of two herds, each of over 100 cows, stated that in no other winter had they experienced so little illness and diseases in their herds; the appearance of the cows certainly added support to this.

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THE FOOTHILLS GRAZING PROBLEM IN INDIA.

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INDIA contains such a variety of climates that it is difficult to convey a general picture of grazing conditions for the whole of it. The climate varies from real desert with a 3 in. rainfall to Cherapunji with its famous 400 in. This paper is concerned with the drier half of the country, in which the rainy seasons are separated by periods of drought of sufficient length to make fodder supply a serious problem. It therefore applies to the Punjab and North-West Frontier, Sind, the United Provinces, Central Provinces, Bihar, Orissa, the drier parts of Bombay and Madras, and a multitude of native states which are included within this vast tract of country (1). Whether the rainfall is 80 in. or 8 in., it occurs in a short series of monsoon storms, after which the country is parched for many months, mitigated to a varying extent by gentler winter rains which are at best unreliable. Winter frost reduces the variety of vegetation in the north-west, and increases the difficulty of keeping animals in condition. Thus, in spite of a more or less regular monsoon, the net result in the Punjab plains and foothills is a climate strangely akin to that of the "South-western Desert" of U.S.A. and the interior range lands of Australia.

Almost every kind of live-stock competes for a living,—milk cattle, plough cattle, water buffaloes also used for milk and plough, sheep, goats, camels, donkeys, mules and pack bullocks, plus huge migratory flocks of sheep and goats which descend from the high hills every autumn to the adjoining plains, like locusts in their numbers and powers of sheer destruction. The better-known breeds of Indian cattle such as Hissar and Danni are bred only in areas where there is practically no common grazing ground left, or are kept as pampered pets stall-fed by the household to which they belong. Where the people have been forced to rely entirely upon stall-feeding they have naturally concentrated upon fewer and better animals. The serious deterioration in the type of cattle wherever common grazing still persists as the usual practice is a most striking and consistent feature of Indian animal husbandry. This deterioration is seen at its miserable worst in all districts containing large areas of wild land too steep or too poor for cultivation, and therefore includes the whole of the Western Himalayas and the many ranges of lower hills further south. The incidence of live-stock to ploughland varies from 0.62 head per acre in Ludhiana, a typical non-forest district, to 0.98 head per acre in Rawalpindi, a forest district. As the farm community alters towards the grazier type, the daily milk output per cow drops from somewhere about 16 or 20 lb. of milk to less than 0.25 lb. This is no exaggeration; the average village cow in the foothills seldom yields more than a *chittank*, which is 2 oz.

Apart from grazing, the food resources for animals comprise (a) straw and stubble from crops such as rice, wheat and sugar-cane; (b) leguminous and other fodder crops; (c) cut grass; and (d) tree lopping. Rice straw is the mainstay in many districts but is not in itself a *maintenance ration*. Lander and Dharmani (2) place the value of Kangra rice straw as being well below this standard which is the minimum digestible protein needed to keep a cow fit when not working; it would not provide for a plough bullock at work nor for a good milker. Wheat straw is somewhat better in food value, but the amount available is sufficient only for a short time after each harvest. The chief fodder crops are *juar* (*Sorghum durra*) and in irrigated tracts berseem (*Trifolium alexandrinum*), shaftal (*T. resupinatum*), and lucerne; again the amount of these fodder crops is in inverse proportion to the amount of wild grazing land available, and the poorer districts have such a hard struggle to



FIG. 1.—A typical Kangra cow and its diet. *Photo* : R. M. Gorrie.



FIG. 2.—Abandoned fields near Duman, district Jhelum, being cut away by gully erosion which is hastened by effects of uncontrolled grazing. *Photo* : R. M. Gorrie.

find enough land for their own food crops, that they cannot grow any fodder. This is a point which many animal-husbandry enthusiasts have failed to grasp.

The value of cut grass is also rather low in the foothill areas, partly owing to the natural poorness of the grass crop from land which is heavily overgrazed for at least nine months in the year, partly owing to the method of harvesting the grass. At the time when hay ought to be made, in the months immediately following the monsoon, the cultivator is busy with his autumn ploughing, so the cutting of grass is inevitably delayed until only the dry bones of the grass crop are left. As it is not possible to alter the agricultural calendar, improvement appears to lie along the lines of grass cultivation by contour ridging and by any other means which will keep the grass green for a longer time. The possibilities for the improvement of wild grasslands along such lines are tremendous, but are so far practically untouched. Possibly the best samples of ordinary foothill grass crops are harvested by the Military Grass Farms from areas which they hold or lease, and the analyses of these show (3) that very few constitute a maintenance ration, although they are above the village average in so far as closure is enforced for the whole year instead of only for the monsoon months.

A peculiar feature of Indian animal husbandry is the dependence in many localities upon tree loppings for fodder. In the oak zone of the lower hills at 4,000 to 6,000 feet, *Quercus incana* and *Q. dilatata*, in the higher hills, *Q. semicarpifolia*, and in the more arid hills *Q. ilex*, are all very heavily lopped, so heavily in fact that one or other is being completely driven out and destroyed over large tracts, for example, *Quercus dilatata* in the Murree hills, *Q. incana* in Kangra. The same thing applies in a still lower zone where *Olea cuspidata*, the wild olive, still persists in face of very heavy misuse in the limestone and sandstone of the Jhelum Salt Range and other arid hilly tracts below 3,000 feet altitude. The combination of persistent grazing, browsing, and lopping under an exceedingly arid climate is more than even this hardy species can stand, and it is disappearing from a landscape already devastated by erosion. Many similar instances could be quoted for the less arid tracts in the other provinces enumerated above; the processes of desiccation, deforestation and inevitable erosion can be seen by any intelligent observer on any train journey across India from north to south or east to west.

The human population of India is increasing at the rate of about three millions per annum. Much of this increase is occurring in the tracts where nature in the first place provided easy conditions for human settlements, namely, a rainfall not too heavy for the ordinary farm crops, and natural grasslands in which cattle thrive and remain healthy. Within the heavy rainfall areas further east, the re-growth of dense tropical jungle and conditions inimical for livestock have discouraged dense settlement. Therefore much of the weight of this increasing population is falling upon the *tension belt* where grassland can persist only under reasonable treatment, and, if once destroyed, cannot reinstate itself as easily as it can under a slightly heavier or better distributed rainfall. Hence over very large tracts of country, natural grasslands have already disappeared and village livestock are dependent upon bush and tree growth for their day to day existence. In most other countries livestock are maintained on a ration of grass, and the bush growth which occurs in the grazing grounds is looked upon as a natural reserve which should be used only in times of acute scarcity; in much of India the last vestiges of shrub growth already form the ordinary daily ration for the village herd. The amount of erosion caused directly through this state of affairs has to be seen to be believed. Figures of torrent intensity for various conditions of the plant cover in the arid Punjab foothills have been published (4) giving the approximate maximum run-off in terms of cubic feet per second per square mile. The Pabbi range is a very low ridge of rapidly eroding Siwalik sandstone and shale.

- (1) Part has been under a régime of afforestation and counter-erosion work for some years ; such land, although not fully covered even when fully protected, yields a run-off of less than 100 cusecs maximum, enables cultivation to be done close to the streams which drain from it, and yields a revenue of one rupee per acre for grass cutting.
- (2) Similar land under a passive régime of protection against grazing but with no active afforestation or gully-plugging work yields a maximum of 600 cusecs.
- (3) Similar land under grazing, partially but ineffectively controlled, yields 1,000 cusecs. Its revenue is one anna per acre for grazing (one-sixteenth of a rupee), and no cultivation is possible within a very wide strip of sandy waste which borders the resulting torrent bed in the flat lands below.
- (4) Where persistent cattle and buffalo grazing has destroyed the cover and reduced the area to slopes of shifting sand anchored only by the relics of scrub jungle, the run-off rises to the alarming figure of 1,600 cusecs. These figures are for small individual catchments of 2 to 10 square miles area, and this last figure therefore represents an extremely high percentage of run-off, in the neighbourhood of 90 per cent of the rainfall for the typical sudden torrential downpour falling on ground previously parched by drought.

The effect of this state of affairs upon the question of water supply is only beginning to be realized, although in a country where water is proverbially worth its weight in gold, one might have expected a more intelligent attitude towards water conservation. In spite of the warnings given by a series of forest officers since the activities of Baden Powell in 1870, the civil authorities, with one or two brilliant exceptions, have failed entirely to grasp the situation, and are only now having it forced upon their notice through the recurring failure of the Punjab canal systems to produce sufficient water for cold-weather irrigation.

There has been a popular impression in the Punjab that the water resources of the province were being husbanded by the Forest Department, but this is being gradually removed with the realization that this Department holds only a small percentage of the total foothill catchments, and even in these its hands are absolutely tied by legally binding but ridiculously generous forest settlements under which effective control of grazing is more or less impossible. The remainder, a very much greater area, lies in village grazing lands and in a number of native states where overgrazing, and other misuse of land such as bad cultivation methods, are even worse than in the Punjab foothill districts. To-day the fringe of the problem has hardly been touched, in spite of very strong recommendations by the Royal Commission on Agriculture for India of 1928. Animal husbandry in its widest sense, (including the control of grazing, the substitution of grass cutting and stall feeding, and the improvement of grasslands), as an obvious preliminary to the improvement of the local livestock has not been tackled.

There is great need for a sound policy of land use with fodder production as one of its main objects. The change from grazing to grass-cutting and stall feeding requires a drastic revision of the whole economic life of the grazing communities, and can therefore only be brought about gradually, but for the welfare of the country as a whole, this change is absolutely essential.

The Punjab Government has already taken steps in this direction by detailing three forest officers to different districts on special duty to obtain closures for grazing through the co-operation and consent of the villagers. In Hoshiarpur in two years some 70,000 acres have been closed in this way, and more recent work in Ambala, Gurgaon, Jhelum and Gujrat districts is also beginning to bear excellent results. These officers are each working in areas where erosion has already reached an alarming

stage, and their work in the villages has been towards a combination of rotational grazing closures, and the reservation of hay-fields, with erosion control, torrent reclamation, stream training, and afforestation projects on a scale suitable to meet the needs of each village or group of villages. Constructive work can be done only on a self-help basis of free labour because the Government cannot afford to undertake it. The two main heads for their activities are (1) to develop fodder resources for local live-stock, and (2) to improve the standard of cultivation in any way which will tend to conserve soil and reduce run-off. Under the first of these two heads the common lines of attack are :—

- (a) Rotational closures of grazing lands belonging either to individuals, village communities, or the Government. Much government land is so heavily burdened with rights as to be uncontrollable except by agreement.
- (b) Partition of *shamilat*, by allocating the common grazing land to individuals to cultivate, or conserve for their own animals ; this has been extraordinarily successful where there is a real scarcity of cultivated land, and has produced some of the finest examples of soil conservation work by individuals, e.g., Mr. F. L. Brayne's work in the Jhelum and Gurgaon districts of 10 to 15 years ago.
- (c) Panchayat or village committee management ; in certain parts the delegation of authority to these committees has been most beneficial.
- (d) Intensive improvement of natural grasslands, including " gully-plugging " to stop active erosion, and the application of the principle of *watt bandi* or contour ridging, so far applied only to farm crops, to the more gently sloping grasslands.
- (e) Development of the tree fodder supply by distributing transplants of suitable tree species, and by controlling the very heavy lopping of the oaks, incidentally is confined to government forest. When these trees occur which in private lands they are carefully lopped on a reasonable rotation !
- (f) Development of the use of green fodder crops and silage. In the poorer parts land cannot be spared for any crop that does not produce human food. Ensilage is being taught extensively by the Agriculture Department but is nowhere popular yet.
- (g) Research on the correct grazing incidence for local types of bush and grass ; given stall feeding for the two hottest and driest months in the year and closure during the monsoon growing period, this incidence could actually be fairly high for the remaining months without causing excessive denudation.
- (h) Restriction of immigrants and 'non-right-holders' livestock ;—a thorny problem where itinerant flocks are welcomed for the manure they bring to the fields they squat in, and where some of the migrant communities have already forestalled us by acquiring nominal holdings of land so as to rank as right-holders.
- (i) Reduction of local herds by encouraging castration of scrub bulls, and by propaganda and demonstration of " fewer and better cattle." The change to grass cutting will in itself be helpful because nobody will cut grass for animals which will give no return in work or milk.

This last item, the reduction of surplus animals, should really be placed first, because if it is omitted the rest of the work will be largely useless. Where progress depends upon persuasion, however, so drastic a suggestion may do more harm than good by antagonizing the whole community.

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REVIEWS

ROOTS OF MEADOW PLANTS IN DIFFERENT HABITATS*

[Reviewer: G. M. ROSEVEARE.]

THE authors' studies were made (1931-36) on an area of approximately 20 hectares situated on the shore of Lake Ladoga and in close proximity to the town of Sortavala, Finland (latitude $61^{\circ} 40'$). The land was long ago reclaimed from forest (by burning) and from fen, but within living memory it has not been used for anything but "natural" grassland: manorial treatment has been non-existent, and the only cultural influence affecting it has consisted in the taking of one cut of hay annually at the end of July or beginning of August. In this area several clearly defined types of grassland vegetation are represented, three of which were chosen for special study, namely, those in which *Antennaria*, *Nardus* and *Alchemilla* respectively are dominant. Mechanical and chemical analyses of the soil were made, and likewise determinations of the soil's natural water content, water capacity, pore volume, water table, soil reaction, and the CO_2 content of the soil air. The soil of the *Antennaria* meadow consists of medium coarse sand, that of the *Nardus* meadow of fine sand, with a lower stratum of loam at a depth of 25 (20) to 30 cm., and that of the *Alchemilla* meadow is loamy or clayey, very rich in humus in the upper layers. The *Antennaria* meadow with its xerophilous vegetation (*Festuca ovina*—*Antennaria*—*Thuidium abietinum* association) represents the dry meadows, the *Nardus* meadow with its xero-mesophilous (*Nardus*—*Deschampsia flexuosa*—*Pleurozium Schreberi* association) and the *Alchemilla* meadow with its meso-hygrophilous plant cover (*Agrostis capillaris*—*Alchemilla pastoralis*—*Rhytidiadelphus squarrosus* association) the fresh or humid meadows. The vegetation is very rich in species; the number of vascular plant species in the three meadows averages 24, 30 and 36 per square metre. In the *Alchemilla* meadow the average number of vascular plant species per sq. dm. is 17, or, counting the seedlings also, 21; that is, an average of 1.1 individuals or aerial shoots per sq. cm. The plant cover is not so close in the other meadow types, but in all, and especially in the humid meadow soils, the root crowding is enormous.

Sixty-one plant species, 36 from the *Antennaria*, 38 from the *Nardus*, and 53 from the *Alchemilla* meadow, were studied for root development. Of these 28 species are common to all three meadow types or to both the *Antennaria* and the *Alchemilla* meadows. Six are hapaxanthic, eleven perennial graminaceous species, and 44 herbaceous plants. The individual root systems were carefully teased out with the fingers or with a blunt knife or needle; length, branching, direction of growth and depth of penetration were determined, and thickness was subsequently determined by the microscopical study of samples in spirit. In spite of the tangled matting of the roots, it was generally possible to free most of them down to the tips of the primary roots. Approximately 500 were carefully exposed in this manner, and some 100 rather more roughly; that is to say, an average of ten root systems per plant species. Some isolated observations were also made outside the specially studied area.

*Linkola, K., and Tiirikka, Aili. Über Wurzelsysteme und Wurzelausbreitung der Wiesenpflanzen auf verschiedenen Wiesenstandorten. [Root system and root distribution of meadow plants in different habitats.] *Ann. bot. Vanamo*, 6. No. 6. 1-207. 1936.

Pages 29 to 124 are devoted to a detailed description of the different root systems in relation to the meadow types from which they were taken, and the principal data are tabulated on pages 134-7.

In the roots studied twenty-two different morphological forms of structure may be distinguished. They fall into three groups: (1) primary root systems; (2) primary and secondary root systems; and (3) secondary root systems. These groups are again subdivided in accordance with the degree of development of the main, lateral or secondary roots, the secondary root systems being classified principally in relation to the grouping of the roots in different earth layers, the manner of branching, the possible existence of dimorphism, and in particular cases other important external characters. In one and the same species different forms of root structure may be found in accordance with age or even locality. One half of the forms determined are found in all three meadow types. The presence of tap roots and of tap-root-like secondary roots is characteristic of the dry meadow. Characteristic of the humid meadows, especially the *Alchemilla* meadow, is a dwarfing or absence of the main roots in the pollachanthic species and in accordance therewith a promotion of secondary root formation even in the dicotyledons, a phenomenon which even leads to the well-known tap-rooted plant, *Trifolium pratense*, and the perennial hapaxanthic species *Cirsium palustre* being transformed into typical secondary-rooters.

Root length naturally varies greatly according to species. The shortest primary roots, 3 to 4 (5) cm., were found in *Trifolium spadiceum*; the shortest secondary roots, 1 to 5 cm., in *Galium uliginosum*; the longest roots, 90 to 155 cm., in *Knautia arvensis*. In one and the same species root length is in general considerably greater in the dry *Antennaria* meadow than in the humid ones, where again it is generally remarkably uniform. Several species, however, exhibit approximately the same length of root in all three localities, but in the majority of these species reduced vitality was apparent in the dry meadow.

In depth of rooting also there are naturally very great differences between the individual species. *Galium uliginosum* has the shallowest roots (not more than 2 cm.); *Knautia arvensis* penetrated to the greatest depth, approximately 115 (142) cm. Of the above figures, the lowest, 2 cm., was recorded for the humid *Alchemilla* meadow, the greatest depth for the dry *Antennaria* meadow.

The average depth reached by each species was determined according to the depth reached by those roots which penetrated furthest, extreme, only occasionally reached depths being excluded. In all three types of meadow, very shallow (0 to 6 cm.) and shallow (6 to 12 cm.) and also moderately deep (12 to 30 cm.) and deep-rooted (30 to 100 cm.) species are found. There is, however, a great difference between the dry and humid meadows as regards general depth of root. In the *Antennaria* meadow deep-rooting is very common; in the two humid meadows, on the contrary, shallow-rooting predominates, as may be seen from the following table:

Meadow type.	Percentage of species which were			
	Deep-rooted.	Moderately deep-rooted.	Shallow-rooted.	Very shallow-rooted.
<i>Antennaria</i>	77	15	0	8
<i>Nardus</i>	8	8	59	25
<i>Alchemilla</i>	9	18	50	23

The above figures apply to one square metre. The percentages for the whole plant stand do not exhibit such differences, since not a few more or less exotic species are represented in the dry meadow, but the same trend is nevertheless clearly indicated.

Although most of the species common to both dry and humid meadows exhibit much deeper rooting in the dry soil, there are still several species which penetrate to approximately the same depth in all three localities. They are for the greater part shallow-rooting species, whose development in the humid meadows is satisfactory, but generally enfeebled in the *Antennaria* meadow. In the two humid meadows the depth of rooting is in the main very uniform, but a few species, notably some of those with tap roots, penetrate to a considerably greater depth in the drier *Nardus* meadow than in the fresher *Alchemilla* meadow. Marked tendency to shallow rooting is generally expressed in the horizontal or slightly oblique position of the main roots, both primary and secondary.

In the great majority of the plants studied, root tips capable of absorption were found from the uppermost soil layers down to the extreme depth reached by the root, being frequently most abundant in the humus upper layers. Only in some of the *Antennaria* meadow species is the principal absorption activity relegated to the greater soil depths.

Breadth of rooting system naturally varies according to species. The small annuals and biennials have a rooting breadth of 5 to 12 cm. only, in most grasses and herbs the breadth is from 30 to 50 cm., in the case of the most vigorous secondary root tufts it amounts to 70 to 100 (120) cm. Rooting breadth in the same plant species is approximately the same in all the localities. The lateral extension of the roots appears to be practically unaffected by the innumerable roots of neighbouring plants, for primary and secondary root branches thrust themselves apparently unhindered sideways through the tangled mat.

The space occupied by the roots assumes on the whole symmetric forms, described as conical, cylindrical-conical, club-shaped, cylindrical, disk-shaped, etc. The size of the root space differs in accordance with the breadth and depth of the root system and varies according to species. The cubic content of the root space occupied by the roots of some species was determined: it varied from 0.1 to 0.2 cdm. in the case of the small hapaxanthic species to 150 cdm. in the case of some deep-rooting, tufted grasses. In many species the size of the root space varied greatly according to locality, as a rule parallel with depth of rooting. The space is generally much greater in the dry meadows.

A study of root weight at different depths gave the following figures:

Meadow type.	Dry weight of the total quantity of roots. Percentage.	
	Depth 0 to 10 cm.	Depth 0 to 15 cm.
<i>Antennaria</i>	68	76
<i>Nardus</i> }	83 to 88	94 to 96
<i>Alchemilla</i> }		

At a depth of 15 (12) cm. a sudden diminution in root bulk was observed in the humid meadows, but not in the *Antennaria* meadow. For purposes of comparison a considerable quantity of root mass from some other moist and definitely wet grasslands was studied, taken from below the 15 cm. level, in some cases at considerable depths, and below the water table in the wet meadow. In general the air-dry weight of the subterranean parts of plants in old grassland exceeds that of the aerial parts several times. This was especially marked in the dry meadow.

Depth of rooting is obviously dependent upon several factors. In the fairly dry, well aerated soil of the *Antennaria* meadow the roots of most of the plant species are enabled to grow downwards through a positive geotropism, and reach, according to the species concerned, more or less propitious soil moisture and, according to their

capacity, various depths. In some species it is observed, however, that positive geotropism is blunted through hydrotropic or perhaps chemotropic stimulation in the uppermost soil layers with their relatively better water conduction and supply of plant nutrients, which results in a lateral extension of the root system at shallower soil levels.

The predominance of shallow rooting in the humid meadows is brought about in the first place directly through a corresponding, and here very frequent, diversion of the principal roots from the orthotropic direction governed by positive geotropism, but partly also by the stunting of the tap roots and inhibition of growth in those secondary roots which maintain their vertical course.

Of the external stimulants which govern the diversion of roots from the perpendicular, the too high carbon dioxide concentration of the soil air at already relatively shallow depths may perhaps be considered the most important. In contrast to the air of the *Antennaria* soil, in which a CO₂ content of approximately 0.2 to 0.3 per cent only was found to a depth of 1 m., the air of the *Alchemilla* meadow soil, for example, has at the beginning of the midsummer period a CO₂ content of approximately 1 per cent at a depth of 15 cm., a concentration which according to Lundegårdh represents the lower limit of toxicity for the root of most mesophytes; in the long wet periods of spring and autumn this concentration is probably attained at much higher levels, and especially at these seasons it may be assumed that the CO₂ content of the soil air increases even in the *Nardus* meadow to concentrations of importance at very shallow depths. The excess carbon dioxide, which is probably attributable to active soil respiration and especially to the greatly increased difficulty of soil aeration under the extraordinarily dense root mat at the surface, produces clearly aerotropic curvatures (probably taking place in spring and early summer especially, when elongation of the roots is most active), and these result in the vertical or slightly oblique position of the roots at shallow levels. That oxygen deficiency, which can also lead to aerotropic curvature in the upper soil layers, is experienced particularly in spring and autumn must also be taken into consideration. Which meadow plants are more sensitive under periodical oxygen deficiency than under high carbon dioxide concentration is, however, as little known as is the degree of their susceptibility. Just as in the *Antennaria* meadow, it is possible that in not a few species the more or less horizontal root growth is hydrotropically governed through the relatively good water conduction of the upper soil layers, or chemotropically through the better supply of plant nutrients in these strata. For certain tap roots the dense structure of the subsoil in the *Nardus* meadow appears to form a mechanical hindrance to development and to enforce horizontal deviation where the loam layer ends. It is possible that in many cases several tropic stimulants act simultaneously, so that the deviation from the perpendicular resulting from geotropism and other tropisms may be regarded, in species having tufts of secondary roots, as of correlative value. If greater root depths are attained in the humid meadows, it is possible that this is due to the presence of roots with relatively greater immunity to high carbon dioxide concentrations or oxygen deficiency.

Root layering was observed in a very modest form only and was not clearly developed except in the *Antennaria* meadow, where depth of rooting in many species was considerable. The absence or poor development of subterranean layering has an analogy in the absence or the very incomplete development of layering in the aerial shoots. Just as the leaves are crowded together in a dense, low stand with no definite stratification, especially in humid meadows, so the roots of the preponderant number of meadow plants seem to enter into spirited competition with one another in the enormously crowded root mass of a shallow soil. The absence or poor development of root stratification seems to offer no hindrance to the presence of a great abundance of species, at all events in the humid meadows; and it may be concluded that for the production of plant associations root layering is not so necessary a condition as it has often been considered.

THE HORMONE THEORY OF VERNALIZATION.

[Reviewer : M.A.O.]

DESPITE the appreciable advances in the study and use of the effect of environmental factors upon plant growth and development following the discovery of photoperiodism, and particularly the announcement of the new principles of plant development by T. D. Lysenko, the underlying physiological causes thereof still remain obscure. Since Charles Darwin stated in 1881 that "when seedlings are freely exposed to a lateral light, some influence is transmitted from the upper to the lower part, causing the latter to bend", and Errera (1907) suggested that a regulating substance (hormone) plays a part in plant economy, a great many facts have been collected to show that hormones carry out some important functions in the physiological activity of plants. It is but natural, therefore, that in the search for the physiological cause, attempts have been made to interpret in terms of hormone activity the phenomena observed in photoperiodism and vernalization. Although at present we intend only to review the latest effort (3) to interpret the physiological cause of vernalization, it should be noted that Krasnoseljskaja-Maksimova (7), in attempting to explain the effect of low temperature on cereals, suggested the participation of special "winter" and "spring" hormones and considered that the heading of winter cereals after vernalization might be due to the destruction in them of "winter" hormones by low temperature during vernalization. In specially designed experiments, however, made by Sereiskii and Sluckaja (11), the existence of these hormones with the properties attributed to them by Krasnoseljskaja-Maksimova has not been confirmed.

Cholodny (1a and 1b), following upon his experiments in which auxin introduced into the root meristems caused rapid development of plants and increased concentration of auxin in the growing point, suggested that "the growth hormone seems to act on cells passing through the first stage of development in such a way as markedly to hasten the rate of development and reduce the duration of the whole life cycle of every cell." All these attempts, however, remained merely speculative until phytohormones secreted by the endosperm were found by Cholodny (2a, 2b), Laibach and Meyer (8) and Pohl (10). The hormone to which Cholodny refers as blastanin is thought to be contained only in the endosperm, and according to Cholodny is not detectable until the water has penetrated into the endosperm; the fact that this hormone was extracted into alcohol by Laibach and Meyer from dry seeds is due to the presence of 12 to 15 per cent of colloiddally-bound water. As Cholodny and Laibach and Meyer showed, blastanin is rapidly absorbed into the embryo during germination and is then transferred acropetally within the organs of seedlings, apparently participating in various processes of growth and development. It was shown by Pohl that this hormone is not produced in the coleoptile, but is given off by the endosperm and activated by the tip.

The discovery that blastanin is so intimately connected with seed germination led Cholodny (3) to set forth a more concrete conception as to the physiological cause of vernalization, some theoretical aspects of which are given below in a condensed form.

Cholodny argues that no matter whether plant development is a continuous, uninterrupted process, as postulated by Ljubimenko, or whether it consists of certain mutually independent serial stages, as advocated by Lysenko, vernalization comes eventually to represent "a certain acceleration of the formative processes, a shortening of the vital cycle of the vegetative organism from germination up to the formation of 'ripe' fruits." Virtually, the rate of development of a plant as a whole is conditioned by the rate of differentiation of the cells of the growing point. Some previous investigations (1a, 1b) showed that the morphogenetical processes occurring

in the growing point are regulated by hormones. Finally, the discovery that blastanin is absorbed by the tissues of the growing embryo has led the author to the assumption that the pre-sowing treatment of seeds must stimulate the accumulation of the hormone secreted by the endosperm in the tissue of the embryo and to postulate that this accumulation is responsible for a rapid completion of development in the plants derived from vernalized seeds.

In order to ascertain the character of the effect of this hormone on morphogenesis, experiments were made in which the roots of maize seedlings grown in a humid chamber at 23 to 25°C. were supplied with blastanin, the control being grown under the same conditions. It was found that the introduction of blastanin into the root meristem appreciably reduced the number of dividing cells; thus, if the number of nuclei undergoing cell division in the roots of the control plants is taken as 100, their number in the roots treated with blastanin for four to eight hours was reduced to 50 or less. The cortical cells vacuolized more rapidly and terminated the phase of elongation in a shorter time, thus causing the forming cells to lengthen not along the axis, but chiefly more or less isodiametrically. The treated roots began to thicken at a distance of 3 to 4 mm. from the tip and developed many hairs. All these phenomena, which could be described as an accelerated maturation of roots, the author traces to some chemical changes in the colloids of the protoplasm and in the nucleus, as affected by the blastanin.

Finally, B. Drabkin (quoted in 3) showed that unvernallized seeds contained blastanin, while no hormones were found in vernalized seeds. As blastanin is transferred at seed germination into the tissues of the embryo, it could be assumed that during vernalization all the hormones were absorbed by the embryo from the endosperm. It is held, therefore, that "arisen to life, but lacking the possibility of normal growth (as a result of insufficient moisture and low temperature), the germ of the yarovized seed absorbs from the endosperm the growth hormones contained there in great quantity. Inasmuch as this substance is expended principally in growth, and since under the conditions of yarovization there was almost no growth, the concentration of the hormone in the cells of the embryo rises considerably above the norm. Increase of the intracellular concentration of the hormone in the growing points causes an acceleration of the passage by the cells of the meristem of the young plant through the first phases of development according to their hereditarily determined sequence. In this way, the interval of time that separates these first phases of development from its later stages, connected with preparation for fruiting, is shortened. The result is that the whole cycle of the plant development is finished sooner than it would be under normal conditions."

Following upon these theoretical premises, some experiments were made to replace the specific effect of vernalizing factors by direct increase in the phytohormones contained in the endosperm. Of these experiments, only two have been fully described (4). In one of the experiments, dry seeds of oats Pobeda, free from their husk, were thrust (for approximately half their length) into moistened pulp of the endosperm of maize grain, kept thus for 36 to 48 hours at 18°C. and then sown on April 29 simultaneously with the control seeds kept for the same time and at the same temperature in moistened sawdust.

The plants from the seeds treated with blastanin at first lagged behind in growth, but in a month they had overtaken and later they surpassed the control plants in size. The experimental plants flowered on June 21, while the control plants were still growing rapidly; when the control plants flowered on July 2, they had again become taller than the experimental plants. All plants were harvested on July 21. Records of yield showed that on the average an experimental plant produced 15 grains, each of 0.34 gm. in weight, and 0.7 gm. of straw, while the control plant

yielded 19.5 grains, each of 0.36 grm. in weight, and 1.98 grm. of straw. Thus, experimental plants flowered 12 days earlier, but their yield of grain, and particularly of straw, was somewhat lower than in the control.

In the other experiment with seeds of the same variety, the phytohormones (hetero-hormones) were induced by soaking dry seeds in β -indolyl acetic acid (1 to 2 mg. of hormone-containing substance in 10 ccm. of water) for 24 hours at 18°C., the control seeds being soaked in the distilled water. After sowing, a temporary lagging in growth was again observed in the plants, but by the time of flowering they were taller than the control. All the plants eared simultaneously and were harvested on July 21, but the experimental plants produced on the average 18.8 grains, each weighing 0.56 grm., and 0.88 grm. of straw, and outyielded the control plant which gave 13.5 grains, each weighing 0.37 grm., and 0.48 grm. of straw. Other experiments with wheat, barley and millet were less conclusive.

These experiments showed that the phytohormones introduced into the embryonic tissues affected the rate and vigour of growth and development, but it is difficult to agree with the investigator's opinion that the effect of phytohormones is in any way "suggestive of the phenomena observed in yarovized plants," and still less with the attempt to interpret vernalization in terms of hormones.

This latter attempt was, as has already been stated, preceded by an interpretation in terms of some specific spring and winter hormones postulated by Krasnoselskaja-Maksimova (7) to account for experiments in which the endosperm of spring and winter and of vernalized and unvernallized cereal grains were interchanged. Similar experiments, however, (11) failed to substantiate this hypothesis. In connexion with the new hormonal theory, the experiments (11) with "compound grains" are rather suggestive. Sprouting wheat grains, vernalized and unvernallized, were halved across and the two half grains were joined in such a way that the "compound grains" contained either both halves vernalized or unvernallized, or one half vernalized and the other unvernallized, either both halves or one of the halves containing the embryo. In all cases the respective time of heading was not changed. The plants from the "compound grains" with a single embryo were taller and heavier than the plants derived from the compound grains containing two embryos, thus showing that the embryo had used the endosperm of both halves. Thus the endosperm, while apparently affecting growth vigour, had no effect on the rate of development; hence the interpretation of vernalization should be sought not in products of the endosperm, but in the changes which occur in embryonic tissue. Some later experiments (6) on the vernalization of embryos separated from the endosperm and grown on agar containing 2 per cent glucose and mineral nutrients seem to show conclusively that "the cause of vernalization by low temperature is entirely inherent in the embryo, and is not dependent in any way on the metabolism of the endosperm or aleurone layer", or on any activity therein.

Undoubtedly, in his theoretical premises, the investigator was misled by an erroneous conception of vernalization which he described as "a certain acceleration of the formative processes," a shortening of the vital cycle of the vegetative organism, from germination up to the formation of "ripe fruits", in other words, identifying vernalization and stimulation. Virtually, vernalization is a pre-sowing completion of part of the developmental cycle and the environmental factors involved therein, although described by Lysenko as biologically indispensable, are not necessarily optimum. The other factors, in the absence of which vernalization can be effected, might, however, affect the progress of vernalization, and vernalization can thus be accelerated by introducing certain factors. The unhappy choice of plants which proved to be typical spring types not requiring vernalization when sown in spring,

and the absence of vernalized controls were also of consequence. Therefore, while admitting the possible role of hormones in development, as regulating factors, and even the stimulative effect of hormones on development, as well as on growth, it is difficult to identify vernalization with "hormonization" and to interpret vernalization in terms of hormones. Nevertheless, the experiments at issue are, both from the theoretical and practical point of view, worthy of careful attention.

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INFLUENCE OF EXTERNAL FACTORS ON SEED-SETTING IN LUCERNE.

[Reviewer : J. M. APPLETON.]

Previous investigations have shown that the systematic production of lucerne seed is most satisfactorily carried out under arid or semi-arid climatic conditions. An investigation was begun at the Ultuna (Upsala) Branch Station of the Swedish Seed Association, Svalöf, to study the factors influencing the blooming and seed-setting of lucerne with a view to the establishment of seed production on a profitable basis in regions of predominately humid conditions. The investigation reported and herein under review was commenced in 1929, but has been discontinued for the present and the results given, therefore, are in some respects incomplete.*

As a general rule the plants considered in this investigation were ordinary population plants, but certain interesting biotype clones and inbred hybrids were also used. The following lucerne types were investigated. Hungarian lucerne representing *Medicago sativa*, Grimm lucerne and Ultuna lucerne representing *Medicago media*. The Ultuna strain is the result of mass selection from local wild populations, the progeny of spontaneous crossing between *M. sativa* and *M. falcata*. Some tests were also performed on *M. falcata*.

TRIPPING AND SEED-SETTING DURING FLOWERING.

A section of the work was devised to study in particular some of the factors which directly or indirectly influence seed-setting, and also to investigate the tripping and seed-setting frequencies and their variations during the period of blooming.

Clones of five different biotypes were used for the observations, which were carried out in two parallel series, (a) the flowering series, and (b) the seed-setting series. In the flowering series the phase extended over the period from July 2 to September 3, and four racemes with their first flowers fully open were marked on each clone every day. The opening, tripping and withering of the flowers on the marked racemes were observed and annotated day by day until all the flowers had wilted. Each day four new racemes were labelled for further observations on the subsequent days. A record was thus kept of successive groups of twenty racemes with an interval of 24 hours between the first openings. In the seed-setting series five racemes with their first flowers fully open were marked on each clone every day, and on every labelled raceme observations were made on seed-setting. For each of the five clones an average was calculated for the racemes marked on the same day (four in the flowering and five in the seed-setting series). These averages were then combined in successive groups each containing five. Group averages were made later. The flowering period was thus divided into ten different stages.

The number of flowers per raceme, which at the beginning of the flowering period was approximately twenty-one, was fairly constant during the first four stages. On about July 25 (stage five), however, a significant tendency towards decrease appeared. The reduction continued until the end of the flowering period, when the number was about twelve.

The tripping frequency was about 52 per cent in stage one, and showed a continuous increase up to the maximum of 74.9 per cent at stage six. Most of the tripping thus occurred in the last week of July. During August the tripping frequency decreased rather rapidly, falling to 43 per cent in stage ten.

*Torssell, Robert. Influence of external factors on seed setting in lucerne. *Lantbrukshögsk. Ann.* 3. 191-241. 1936.

The seed-setting frequency was calculated from the relation between the number of pods observed and the number of flowers per raceme found in the flowering series. The middle of July was found to be the best time for seed-setting. The seed-setting frequency decreased after this time.

From studying the number of pods per raceme in the different stages of flowering it appears that the decrease in the seed-setting towards the end of the period is in reality even greater than is indicated directly by the data of the seed-setting frequency. This is due to the decreasing number of flowers per raceme previously mentioned as occurring during the later part of the flowering period.

If attention is also paid to the quality of the seed, the decline in seed-setting during the latter half of the flowering period is still more evident. Quality as measured by weight shows rather definitely that seed from the first four flowering periods was heavier than that from the remainder of the periods.

The development of the observed phenomena during the flowering period was essentially the same in the five biotypes. Certain small differences such as earliness have occurred, but they are not considered to be important. On the other hand the biotypes examined have displayed important differences in other characters affecting seed-setting. The tripping frequency was higher than expected, and it was found that from three to ten times as many flowers were tripped as pods set, which shows that the conditions for seed-setting were unfavourable. Although the results were obtained from particularly exposed inflorescences and therefore may not be applicable to the plant as a whole, they show nevertheless that in this case poor seed-setting was not caused by low tripping frequency.

In the material used in this investigation neither a positive nor a negative correlation was found between number of flowers per raceme and seed-setting.

AGENCIES AFFECTING TRIPPING FREQUENCY.

1. *Influence of climatic factors on tripping.* No direct relationship was found between sunshine, temperature or precipitation and tripping frequency. Intermittent rainfall of a certain intensity is the only climatic factor which may be assumed to have a direct effect. The tripping frequency is probably influenced directly as well as indirectly by a number of different climatic agencies with more or less extended after-effects. When the climatic factors vary widely, so that the effect of first one and then the other predominates, it is evident that the climatic influence must become very complicated, but it is difficult to ascertain the effects of each single factor.

The results obtained concerning the influence of certain climatic factors on the tripping frequency do not indicate that the periodicity in tripping which was noted is a direct function of climatic conditions, but this does not preclude the assumption that they exercise an influence over the development of periodicity.

2. *Efficiency of insects in tripping.* Automatic tripping. For this experiment, stands with moveable glass roofs were used. The stands had open sides, which were in some cases covered by gauze to prevent humble-bees, honey-bees and other large insects from having access to the flowers. On two selected plants, half the branches were enclosed in the tent, whereas the remaining stems were left outside. The material represented two very different biotypes; both Ultuna lucernes were investigated, one with yellow flowers and a strong scent of honey, and the other with blue flowers, a faint scent of honey, a comparatively poor seed-setting capacity, but with a very sensitive mechanism in the flower.

It was quite obvious that the insects preferred the flowers under the roof when the weather was wet and cold, whereas the flowers outside the roof attracted a greater number of insects when the weather was dry and warm. Where insects were admitted the tripping frequency was significantly increased.

The results obtained when insects were freely admitted to the flowers support the conclusion that low tripping frequency is caused by the absence of insects rather than by the isolation of the flowers.

As these experiments comprised only two biotypes and were made during two years only, no very definite conclusion as to the way in which tripping is generally brought about can be drawn from the results. However, the experiments with the yellow-flowered, honey-scented type showed that the role played by insects in tripping is of primary importance. The blue-flowered weakly-scented type, with its very sensitive mechanism and representing a more rare type than the former, offers very interesting breeding possibilities.

Considering the experience of other investigators and with a view to the results obtained it seems likely that, under the climatic conditions prevailing at Ultuna, tripping is usually accomplished by insects and seldom automatically.

3. *Possible causes of the periodic variation in tripping and the relative influence of various agencies on tripping frequency.* As the tripping of the lucerne flower is, in many cases, highly dependent on insect visits, it might be assumed that the periodicity in question was due to increases or decreases in the number of insect visitors. If the influence of the insects was actually a dominating factor, it should be possible to detect some relation between the tripping frequency and the weather conditions which favour the activity of the insects. This relationship was not found and the question of the role of the insects in this particular instance must be left open until the results of continued investigations are available.

It further remains to examine the possibility that the primary causes of periodicity are the gradual changes within the plant during the process of flowering. The transition of plants from a vegetative to a more reproductive stage, from the beginning of the flowering period to the end, may be assumed to result in a change in the turgidity of the flower, thus affecting the ease with which tripping may be accomplished. The nature of the curve representing tripping frequency seems to be affected by the kind of external conditions under which the test is carried out. In this way climatic factors probably acquire a greater direct importance.

RELATION BETWEEN TRIPPING AND SEED-SETTING.

A review of the literature is given concerning the extent to which the explosion of the flower mechanism is necessary for seed-setting, and an investigation which was begun at Ultuna to study this problem is discussed in detail. The material used can be considered as fairly representative, as it comprised twenty seven different plants from different populations and the results cover a period of four years. Consequently it can be stated that in the locality of Ultuna under the conditions described, fertilization without tripping occurs so infrequently that the explosion of the flower must be considered a prerequisite to satisfactory seed-setting. The results agree with the experience obtained in most other localities where this problem has been investigated. The differences which do occur might perhaps be ascribed to variations in climatic conditions. It is suggested that under proper conditions the membrane of the stigma bursts automatically without the aid of external mechanical agencies; this is followed by stigmatic secretions necessary for the germination of the pollen.

CORRELATION BETWEEN TRIPPING FREQUENCY AND SEED-SETTING FREQUENCY.

As has already been shown there is generally a very low seed-setting in lucerne when the flowers remain unexploded. It would appear therefore that a greater tripping frequency should result in an increased seed-setting frequency. This assumption is supported by results from experiments in which artificial tripping of the flowers resulted in an appreciable increase in seed-setting, whereas the exclusion of insects caused a decline.

The correlation between tripping and seed-setting frequency was investigated at Ultuna in the years 1927 and 1932. As the tripping frequency of the various biotypes varies considerably it was necessary that the correlation of seed frequency to tripping should be calculated for each separate biotype. A statistical interpretation of the results is given and discussed. The correlation was found to vary from month to month and the general conclusion drawn is that the tripping of the flowers is a fundamental condition for seed-setting, but the results show clearly that at Ultuna seed-setting is limited by other important factors as well.

RELATIONSHIP OF CERTAIN METEOROLOGICAL FACTORS TO SEED-SETTING.

From the results already discussed it seems obvious that the factors adverse to seed-setting at Ultuna are meteorological in nature. As the cultivation of lucerne seed at Ultuna has been very irregular in regard to acreage, methods of cultivation and material, no very strict comparison between climate and seed yield can be drawn in this case. As an illustration of the effects of meteorological conditions it may, however, be noted that in the ten-year period 1926 to 1935 the highest seed yield was obtained in the years 1926 and 1935, which are the only years showing a higher mean temperature and less rain than respective normal values for June, July and August.

Among the climatic factors, humidity is the most important, a condition similar to that found by Engelbert (*Herb. Abstr.* 2. 137. 1932) in Ontario and Carlson (*Herb. Rev.* 4. 166-8. 1936) in Utah. The unfavourable effects of excessive humidity on the plant during the seed-setting period at Ultuna are described. A laboratory experiment was conducted to show the behaviour of pollen when soaked in water. Pollen injured by water exploded to a certain extent, and it also appears that the amount of pollen exploded varied greatly in the different biotypes during the period in question. It is interesting to note that individuals belonging to the same family behaved similarly.

To what extent pollen is damaged in the field through explosion caused by water, and what the differences stated might mean to seed-setting in wet years are questions which still remain unanswered.

SEED PRODUCTION IN HUMID CLIMATIC REGIONS.

It was pointed out that seed-setting is closely dependent on meteorological factors. Consequently, for the production of lucerne seed the most favourable climatic situation and the most suitable soils should be found. It is very important that localities which afford the best possible combinations of climate and soil are effectively utilized, for even if such localities are confined to comparatively small areas, they are still a very valuable asset.

Judging from the results obtained it does not seem necessary to take any particular measures in order to promote the tripping of the flowers. It is quite possible, however, that such measures may be required under a different set of climatic conditions. The breeding of strains with pollen not so very dependent on meteorological conditions appears quite possible and is advised.

NITROGEN ON SEED PLOTS OF *FESTUCA RUBRA* AND *POA PRATENSIS*.

[Reviewer : R. PETER JONES.]

In *Svensk Frötidning* in 1933, Nilsson-Leissner reported on some manurial experiments with red fescue carried out partly in Wales and partly at Svalöf, Sweden. In both series of experiments applications of nitrogen to such crops were not remunerative. In several instances nitrogen directly reduced the seed crop, and where this did not occur its effect on seed yield was either *nil* or relatively insignificant. In the experiments conducted in Wales, in a broadcast stand a small dose of nitrogen had a favourable effect, while a large dose operated in the negative direction. Nitrogen promotes vegetative development in particular and in rhizomatous grasses, such as *Festuca rubra*, the formation of new tillers ; on the other hand it reduces the number of panicle-bearing shoots and therefore in certain cases seed setting as well. This explains possibly also to some extent why a more favourable result was obtained in a dense broadcast stand than in a stand with rows 40 cm. apart. In broadcast seed plots the whole of the ground is interwoven with tillers and roots and the nutrient content of the soil is therefore utilized to a great extent ; in drilled plots the space between the rows is kept fairly open by means of cultivation, so that a certain reserve of nutrient is always available. A small dose of nitrogen applied to the broadcast plots promotes in the dense stand in the first place stem and panicle formation (a certain minimum of nitrogen is required for this), but if the dose is increased, the supply of nutriment in the soil becomes so abundant that additional rhizomes are formed and stem formation is therefore retarded. In drill-sown plots this often occurs following the application of the small dose.

In order to investigate this question more closely the seed production trials at Svalöf have been continued year after year. Two grass species with tufted, non-rhizomatous growth—*Phleum pratense* and *Dactylis glomerata*—and two typical rhizomatous grasses—*Festuca rubra* and *Poa pratensis*—have been tested.

The results with the tufted grasses have always been those expected, namely, that increased doses of nitrogen have without exception produced larger seed yields. By increasing the dose of nitrogen from 100 to 200 kg. saltpetre per hectare the seed yield has risen on the average by 15 to 20 per cent, with an increase of 400 kg., by 40 to 50 per cent—in certain cases even to 100 per cent. With the rhizome-forming grasses the effect has been much less marked, and on the average has proceeded in a negative direction. A more detailed report on these trials might therefore be of interest.

The trials with *Festuca rubra* and *Poa pratensis* were sown in rows 40 cm. apart in a nurse crop of early barley or early Norrland oats. Both in the autumn of the seeding year and repeatedly during the harvest years hand hoeing was carried out between the rows. Superphosphate and potash were applied equally to all plots early each spring, while the different amounts of nitrogenous fertilizer in the form of nitrate of lime were applied at the beginning of April. The seed was harvested by hand as the different plots ripened. The yield figures refer to threshed and cleaned seed. In all the varieties the favourable effect of nitrogen on the vegetative growth of the grass has been particularly marked. On the other hand this by no means applies to the yield of seed, as is shown by the figures in the table.

*NILSSON-LEISSNER, G. Några försök med kvävegödsling till rödsvingel och ängsgröefröodlingar. [Experiments in nitrogenous manuring of seed plots of *Festuca rubra* and *Poa pratensis*.] *Svensk Frötidning*. 6. 29-31. 1937.

Seed yield of pasture grasses at Svalof with different nitrogenous manuring.

Variety and harvest year.	Kg. nitrate of lime per ha.				
	100	200	400	200	400
	Absolute numbers, kg. seed per ha.			Relative numbers (yield with 100 kg. nitrate of lime = 100).	
Festuca rubra.					
Svalöf pure bred.					
1931	72	77	67	107	93
1932	415	459	497	111	120
1933	232	232	221	100	95
1934	360	382	368	106	102
1936	709	611	625	86	88
Average :					
1931-1936	358	352	356	98	99
1933-1936	434	408	405	94	93
Viking.					
1933	495	430	529	87	107
1934	626	493	534	79	85
1936	786	868	983	110	125
Average					
	636	597	682	94	107
Poa pratensis.					
Commercial.					
1933	97	96	108	99	111
1934	247	211	204	85	83
1936	146	124	186	85	127
Average					
	163	144	166	88	102
Skandia.					
1933	73	54	91	74	125
1934	176	169	170	96	97
1936	208	202	261	98	125
Average					
	152	142	174	93	114
Svalöf No. 177.					
1933	57	61	58	107	102
1934	226	224	221	99	98
1936	173	237	276	137	160
Average					
	152	174	185	114	122
Svalöf No. 223/33.					
1933	79	89	87	113	110
1934	362	340	321	94	89
Average					
	221	215	204	97	93
Svalöf No. 244/57.					
1933	73	103	82	141	112
1934	213	196	202	92	95
Average					
	143	150	142	105	99

The trials were sown in 1930, 1932 and 1934, and harvested separately for two years. In 1935, however, seed setting was so poor and the yield figures obtained

varied so greatly that they could not be included in the comparison. The first-year leys have throughout given a poor seed yield, which was much lower than that of the corresponding two-year ley. This has been the case in particular with *Poa pratensis*, which for the rest too in the latter ley gave unsatisfactory results. As regards *Festuca rubra* it is obvious that Viking is a much better seed setter than the Svalöf pure-bred strain, a fact which has been confirmed in cultivation on a large scale. On an average for the years 1933, 1934 and 1936 it gave approximately 50 per cent more seed than the latter strain.

Before passing on to a closer examination of the figures in the table, it should be pointed out that it is very difficult to obtain uniform trials in seed crops of pasture grasses and that therefore the variation between individual replications of the same treatment may often be considerable and the experimental error quite large. Certain values in the table may therefore in some cases have been strongly influenced by this circumstance so that some relative numbers also may be slightly misleading. Such a case, in which the author is of opinion that the yield is calculated too low, is, for example, the value for *Poa pratensis*, Svalöf No. 177, with the smallest dose of nitrogen in 1936, while *P. pratensis* Svalöf No. 244/57 in 1933 with the intermediate dose of nitrogen probably received too high a value; Svalöf pure-bred *Festuca rubra* with the smallest dose of nitrogen in 1932 has possibly in the same way been placed at a disadvantage to some extent. If, however, such inequalities be disregarded and only the average figures of the different varieties which, broadly speaking, must be regarded as pointing in the proper direction, be taken into consideration, it is quite clear that on the average the nitrogen gives a very poor return on these seed plots. On the average of five harvest years for Svalöf pure-bred *Festuca rubra* the yield of seed with all three different doses of nitrogen is almost exactly the same. Viking *F. rubra* shows some, although only a slight, increase in yield of seed with the largest dose, but this is really attributable to the results in 1936, when the nitrogen by way of exception had a very good effect. The *Poa pratensis* varieties also behaved in about the same way as the *F. rubra*, and generally speaking gave a very poor return for nitrogenous manuring, although the larger dose of nitrogen in 1936 increased the seed yield quite appreciably.

Compared with the uniform and relatively potent favourable effect of nitrogenous manuring on *Phleum pratense* and *Dactylis glomerata* seed plots, obtained in the same trials for six years in succession, it is particularly obvious that the nitrogen, as applied here, did not function to nearly the same extent (and frequently did not function at all) as a means for increasing the seed yield in the rhizomatous pasture grasses, *Festuca rubra* and *Poa pratensis*. This is not to say, however, that it is not possible that other methods of application of the nitrogen to such seed plots might give better results. Experience has shown that applications of nitrogen in the late summer of the seeding year and during subsequent years after harvesting of the seed contribute appreciably to a better overwintering during the following winter, and thereby to a better stand and better seed yield in the following year. As it has now been established by many series of experiments both in Sweden and Denmark that the most suitable time for nitrogenous top-dressing of autumn wheat is not, as was generally believed previously, at the beginning of the vegetative period in the spring, but, for example in Scania, in the middle of May, it may also be supposed that approximately the same holds good for seed plots of pasture grasses. It is, therefore, conceivable that a considerably better result might be obtained if top-dressing had not been carried out at the beginning of April but a month to six weeks later. Further experimentation is necessary to elucidate this point.

In what has been said above, the writer merely wished to point out that to say the least the early top-dressing in the spring is less economic than might have been expected from experiences in seed production of hay grasses. Accurate and comprehensive experiments in this sphere are particularly desirable.

METHODS FOR ESTIMATING YIELD OF GRASSLAND.

[Reviewer: R. PETER JONES.]

IN THE paper under review, Giöbel* refers first to some experimental methods for direct determination of the volume of grass production, and then discusses experiences from trials with grazing animals and the desirability of a combination of the two processes.

For the quantitative measuring of grass production under true grazing conditions, many different expedients are available. The following methods of procedure have been tested.

1. Separating off for a longer or shorter period by means of movable fences of certain parts of plots, the remaining portions of which were grazed.
2. Cutting of certain portions of each plot immediately before and after grazings had been carried out.
3. Laying out of trials in two or more complete replications which are alternately grazed and harvested by cutting.

1. *Use of control cages.*

The construction of the cages has been described by Elofson (Nord. Jordbrugsforskning 1926-7, p. 457). The method consists of moving the cages annually, or, if so desired, after each grazing. To obtain reliable results a number of cages are necessary for each experimental moment, and the plots on which the cages are moved from place to place must be fairly large. The costs are comparatively high and the method has been used only to a limited extent. It has proved advantageous in testing the yield of pasture leys in harvesting hay for winter fodder.

2. *Plot trials on grazed folds with cutting of certain portions before and after grazings had been carried out.*

Fences are unnecessary with this method, but the experimental area is grazed contemporaneously with the fold. Cutting—or sampling—is carried out on certain portions of the plots immediately before and after the beginning and end of the grazings. Information is obtained not only regarding the volume of grass production in itself, but also as to the amounts of pasture grass which are left behind by the animals. In trials of this kind the row method possesses definite advantages compared with the checkerboard method, particularly when machines are used for cutting.

In sampling, which is done either by hand or by machine, the harvested areas are constantly changed within the plot. The size of plot may vary as desired, but 20 sq. metres (2 × 10 metres) frequently appears to be sufficient.

The frame used by the Swedish investigators has an inside area of 0.1 sq. m. and the samples are distributed haphazard. Ten such samples are taken for one yield determination. A number of determinations can be carried out for each plot and representative results obtained while only a small portion of the total area of the plot is cut, the remainder being grazed and used for after-sampling.

Although the method possesses certain important advantages, its usefulness is restricted. It has been used with advantage in Sweden in trials with seeds mixtures and varieties and also when matters regarding palatability are in question. For manurial trials it has serious drawbacks.

GIÖBEL, Gunnar. Metoder för försöksmässigt bedömande av gräsmarkernas avkastning. Några erfarenheter om hittills använda försöksmetoder. [Methods for estimating in experiments the yield of grass fields. Some experiences of experimental methods employed hitherto.] Nord. Jordbr. Forskn. 1935. No. 4-7. Beret. Nord. Jordbr. Forsk. 5. Kongr. 820-37.

3. *Trials with alternate cutting and grazing.*

This method is a modification of the old cutting trial method. Instead of cutting a trial for several consecutive years, cutting and grazing are carried out in alternate years. With this method it is advantageous to lay out the trial with two or three complete replications, which are alternately cut and grazed. With three replications (each with the same number of plots) one can be cut each year, while cutting and grazing can alternate on the other two. Or two replications can be grazed every year, while one is cut. As a rule, however, satisfactory results are obtained with annual alternation.

In laying out the trial, the checkerboard method or the row method may be used according to circumstances. Both have been employed by the Swedish Grassland Society, but most frequently the former with plots of 25 sq. metres (5×5 m.). New trials are laid out according to R. A. Fisher's system with blocks, as this would appear to make possible or facilitate the carrying out of a number of experimental combinations, for example, liming and the application of farmyard manure together with other manuring.

An example taken from the 1934 harvest will make clear in what direction alternation of grazing and cutting operates in comparison with constant cutting. The figures cited below are the average of three trials which are identical with one another, but laid out at different centres in Sweden, and the object of which is to ascertain the effect of artificial fertilizers applied at different times during the vegetative period. The manured moments b—e thus receive the same amounts of the fertilizers in question (P + K + N), but the distribution in spring and summer is different. The total yields were in fact equal on these moments, but the distribution of the grass production during the summer was essentially different.

	Moment <i>a</i> unmanured.		Moments <i>b—e</i> manured.	
	Green mass dt/ha.	Rel no.	Green mass dt/ha.	Rel no.
Constant cutting	199	100	285	100
Alternate grazing and cutting	289	140	357	126

Thus through the alternation of grazing and cutting, the yield has been raised considerably above that obtained with repeated cutting. This is particularly striking for the unmanured moment where the increase was relatively greatest. This fact is shown further by a comparison between the yields on unmanured and manured moments in the respective parts. The relative numbers are :

					Moment <i>a</i> unmanured.	Moments <i>b—e</i> manured.
Constant cutting	..	..	..	..	100	143
Alternate cutting and grazing	..	..	..	..	100	128

The same tendency has been traced in all the cases where similar comparisons have been made. The results therefore show clearly that repeated cutting during a long period leads to an intensification of the effect which fertilizers exert, while with grazing the opposite happens or a certain levelling out takes place. All this is connected in one case with the removal from the trial of the cut grass and in the other case with the influence of the grazing animals, and of course more particularly with the restoring on the spot of the greater part of the plant nutrients which the animals had taken up with the grass. The unmanured moment, which in itself has

given considerably less pasture to the animals than the manured moments, receives as large an amount of droppings as the others, and is therefore particularly favoured by the grazing, on account of which the equalization occurs. Through the alternation of grazing and cutting the results should, however, broadly speaking, be quite representative.

A drawback which always accompanies the grazing of a trial lies in the inequalities caused by the droppings of the animals. If spreading of the excrement be carried out carefully and immediately after each grazing, the effects are reduced to the minimum. It is not possible to weaken the effect of urine, but it disappears relatively quickly, and even during the winter has been somewhat diminished. It is in fact only the first cut in the spring which is affected by the droppings. Cutting should be carried out at least four times a year in order that the grass may possess the character and properties of pasture grass. Further, it is important that the first cut should be taken sufficiently early.

TRIALS WITH GRAZING ANIMALS.

When the grazing trials of the Swedish Grassland Society were initiated, two possibilities presented themselves, namely, the setting up of trials with a separate animal group for each moment of the trial ("the group system") or with only one animal group which was allowed to graze all the moments of the trial ("the period system"). Although the former method appeared to be more thorough and better, assuming that adequate areas and animal groups of equal value could be procured, in the six trials, which have now been in progress for eight to nine years, the Society has used the latter method, as this was the only one which with the utilization of milking cows and with the resources available could be considered practicable. All these trials had reference to the question of nitrogenous manuring of pasture leys and the majority of them comprised three experimental moments with two replications. The idea of the trials was to measure the time which the animal group requires to graze the different folds, when the degree of grazing on all remains the same. It is taken for granted that the production of the animals is at the same time carefully controlled in order to determine eventual changes. In proportion as such changes do not occur to any great extent, the time in the first place gives a relative measure of the supply of grass on the different moments. Animal production can afterwards be examined in detail and the result expressed in kg. milk, live weight, etc., or computed in food units per hectare.

The Society hitherto has used only milking cows in its trials, horses being employed for after-grazing; sheep and young cattle have never been utilized as grazing animals.

Judging from the experience of the Society, the following points are of importance :—

(1) Trials with animals are most suitable in investigations where a distinct result is to be expected from the treatments carried out. Hitherto the Society has used this method only in connexion with nitrogenous manuring tests and then with great differences between the manurings.

(2) Only a small number of moments should be included in the trial. The Society's earlier trials comprised three moments with two replications, but the most recent trials contain two moments with three replications.

(3) The grazing areas which are divided up into experimental folds should be as uniform and homogeneous as possible, so that the folds are of equal value, not only as regards soil and botanical conditions, but also as to situation, slope of the ground, watering facilities, etc.

(4) The fold should be at least 0.5 ha. in size; 0.8 to 1.0 ha. would be still better. In the most recent trials of the Society the folds are 0.9 and 1.3 ha.

(5) For the experimental group, older, quiet milking cows giving a high yield should be selected. Sick and bad-tempered animals must be exchanged immediately or removed from the group.

(6) The size of the experimental group should be calculated according to the productive capacity of the ley in question. The cultivated pasture leys on which the Society's trials were laid out showed generally a yield of 2,500 to 3,500 food units per hectare, and on these leys it was found suitable in the spring to begin with five cows per hectare of the total area of the trial. The weather during the spring can of course exert an influence. The number of cows is subsequently reduced so that it corresponds to the supply of pasture during the later stages of the vegetative period.

(7) The sequence of grazing the experimental folds should during the period of the trial be the same if possible. Grazing begins on the moment which shows the earliest or largest supply of grass in the spring; in the Society's trials, therefore, on the folds most heavily manured with nitrogen. The number of grazings should normally be about six to seven per season, and the period during the early part of the summer should be much shorter than during the latter part of the summer.

(8) In the estimation of the most suitable time for moving the animal group from one fold to another, the degree of grazing should be taken into account in the first place, and also the milk yield. When a tendency to decline is noted, moving should not be delayed. The change should be made immediately after a measuring of the milk yield. Any grass remaining can be grazed by horses.

(9) Trials of this kind should extend over a long course of years, at least a five-year period, when errors which may arise owing to animal variation, changing weather conditions, variations in degree of grazing, etc., are reduced materially. Further, it is desirable that the trial should be under the management and supervision of the same personnel during the whole period of the trial.

(10) A combination of animal trials with measuring of grass production on various folds appears under all conditions to be particularly desirable. In the trials conducted by the Society up to the present, grass production has been measured by cutting the control cages, and also in some places by taking samples according to the frame method before and after each grazing. In the most recent trials at Hammarby, the animal trial has been combined with a large plot trial for alternate cutting and grazing, which to make the investigation complete comprises several moments besides the two included in the animal trial.

As is evident from what has been stated above, the possibilities of carrying out the experimental method with grazing animals (cattle) are very restricted. The places where large trials of such a kind can be conducted during a course of years are relatively few, and the method is therefore not adapted for "local" trials in the ordinary sense, although trials of that kind are of considerable interest from the demonstration point of view. The greatest value and merit of the method lie in the fact that the trial is carried out under the conditions obtaining in practice on relatively large areas, and that the quantities which are measured are precisely the products which are obtained in pasturing and which possess a directly rateable economic value.

GRASSLAND RESEARCH IN KENYA.

[Reviewer: J. M. APPLETON.]

THE Annual Report of the Kenya Colony and Protectorate Department of Agriculture for 1935 contains the report of the Agricultural Officer in Charge of Grassland Improvement (D. C. Edwards).

The main problems are:

(1) *Areas of European settlement.* In the high altitude regions, the development of intensive management by the production and maintenance of Kikuyu grass (*Pennisetum clandestinum* Hochst.) and indigenous clover pastures; in the areas of intermediate climatic conditions, intensive management by utilization of the natural herbage, and the establishment of sown pastures; and in drier areas, where intensive management of grazing is not possible, first and foremost the conservation of fodder for use in the periods of scarcity, and secondly the control of grazing on extensive lines to prevent deterioration.

(2) *Areas of native occupation.* In the moist high-altitude regions, and the areas of comparatively high rainfall at lower altitudes, the requirements are essentially similar to those of the European areas. With the progress of mixed farming among the agricultural tribes which occupy these areas, intensive grazing methods become increasingly necessary. Vast drier areas of the country are occupied by the pastoral tribes; here the main requirement is control of grazing on extensive lines by the application of a comprehensive plan, compatible with the nomadic habits of the tribes concerned.

Conservation of fodder for use in periods of scarcity is very closely connected with grassland management in Kenya under both European and native conditions of farming. Considerable advance has been made in this direction in the European areas, but there is still too great a tendency to rely on the pasture as the main and often the sole source of food for stock throughout the year.

CENTRAL GRASSLAND STATION AT KABETE.

The work at this Station bears chiefly on the problems of high altitude and intermediate conditions of the country. The herbage over practically the whole farm consists of *Pennisetum clandestinum* with varying proportions of indigenous clover (*Trifolium Johnstonii* Oliv.), although there are indications that where the soil fertility has fallen other grass species are tending to displace *P. clandestinum*.

High altitude (Kikuyu grass) areas. Experiments on various intensities of grazing of degenerate *P. clandestinum* herbage have shown that (a) heavy concentration of stock has resulted in distinct improvement of the herbage with regard to the proportions of this grass and *T. Johnstonii* and (b) areas of the grass allowed to remain ungrazed rapidly revert to inferior species. Farmyard manure at the rate of 20 tons per acre has produced a definite increase in bulk of herbage. Ammonium sulphate resulted in a darker green colour, but no marked increase in yield. Superphosphate gave temporary increases in the proportion of indigenous clover, particularly when accompanied with potassium sulphate.

Three distinctly different types of Kikuyu grass and indigenous clover have been observed and are now under investigation.

Rhodes grass (*Chloris gayana* Kunth) has been tested with seven different legumes. The most promising from the standpoint of hay production is the indigenous *Indigofera tettaensis*, Klotzsch.

Further trials are in progress in which various mixtures of Rhodes grass and *Amphilophis pertusa* Stapf are being used with *Lespedeza* species and lucerne.

A description of the succession in the areas of high moisture and low temperature is given in "Report on grassland improvement in Kenya, 1934," by D. C. Edwards, in the *East African Agricultural Journal* for Jan., 1936.

Intermediate areas. Connected with these regions of the country, in addition to preliminary trials under nursery and field conditions, other experiments have been commenced. A series of ten one-tenth-acre grazing plots have now been successfully established, on which it is intended to compare the behaviour of different grasses under grazing conditions. In order to make a detailed comparison of the seasonal yield of eight grass species, a series of small plots have been established in a randomized block arrangement. Three clearly different strains of Rhodes grass which have been found are included in these seasonal yield experiments.

Six types of fodder crops for feeding green and as silage in the high and intermediate areas are being compared on the basis of yield of green and dry matter.

Ten species of pasture plants of proved seed-producing quality have been established. The majority of indigenous species either produce little viable seed or the seed ripens unevenly and is partially shed before it can be harvested. In the past season, unevenness of ripening resulted in poor crops of seed.

An investigation was conducted at the Ngong Animal Husbandry Centre to determine the effects of different intensities of grazing and of grass burning on the natural herbage which is here dominated by *Themeda triandra* Forsk. (red oat grass). Results are now being compiled.

Comparatively dry areas. (Experimental Station at Naivasha.) Drought resistance experiments on sown and planted species have shown that Rhodes grass is the only type which has survived; it is believed that if satisfactory establishment can be attained, it may prove a very useful type in the dry districts.

The outstanding result from renovation experiments conducted, following attacks by locust and drought, show that *Cynodon plectostachyum* (star grass), which is dominant in a limited area, recovers remarkably. No advantage was gained by attempts to establish artificially other species in this area.

Manurial experiments have shown that the use of fertilizers is not an economic proposition in these dry areas, moisture being the limiting factor. Intensive management is also likely to be impracticable.

WORK AT KITALE, NJORO, AND ANIMAL HUSBANDRY CENTRES.

Kitale. This centre is representative of the greater part of the Trans Nzoia area in general. It is situated at an altitude of just over 6,000 feet, and has an average rainfall of approximately 45 inches. Species important in the herbage are *Themeda triandra* Forsk., *Hypparrhenia filipendula* Stapf and in parts *H. Ruprechtii* Fourn. From an examination of the observational plots of pasture plants, the following species appeared to be most successful. *Cynodon* sp. (local), *Paspalum dilatatum* Poir, *Brachiaria brizantha* Stapf, *Chloris gayana* Kunth, (Trans Nzoia strain), *Setaria* sp., *Chloris gayana* Kunth (Australian strain). Of these species, *Paspalum dilatatum* is distinctly more successful under Trans Nzoia conditions, and although not included in this series of plots, *Melinis minutiflora* (molasses grass) is also better suited to Trans Nzoia than to Kabete and a number of other conditions. It cannot be claimed that a successful legume has yet been found.

In grazing paddocks at this centre, the herbage consists mainly of the following species which are, as yet, little affected by the grazing factor: *Hypparrhenia filipendula* Stapf, dominant or co-dominant with *Themeda triandra* Forsk., *Trichopteryx kagerensis* K. Schum., frequent, *Brachiaria brizantha* Stapf, frequent, *B. soluta* Stapf, occasional, *Cynodon plectostachyum* Pilg., occasional, *Digitaria scalarum* Chiov., occasional, *Eragrostis tenuifolia* Hochst., occasional.

In artificially established pasture, *Pennisetum clandestinum* has remained strongly dominant over two or three years, and *Melinis minutiflora*, *Brachiaria brizantha* and *Paspalum dilatatum* are all occasional in occurrence.

Plots of Napier grass, lucerne and *Panicum trichocladum* have been tried as reserve fodder for dry periods, but only the first has given satisfactory results in preliminary trials.

Njoro and Sub-stations. This centre is situated at an altitude of 7,200 feet, with an average rainfall of just over 37 inches. The dominant species in the herbage is *Themeda triandra*, except in places where recent disturbing factors have been at work.

At Njoro the concentration of animals, as in intensive grazing, results in a change from *T. triandra* to an undesirable coarse grass stage in which *Pennisetum Schimperi* A. Rich. is dominant. This stage cannot be successfully converted to the higher kikuyu grass stage as in the moist areas of high altitude, with the result that the coarse *Pennisetum* occupies the land to an increasing extent, and the herbage deteriorates for the purpose of grazing.

At Rongai, a sub-station which is drier than Njoro, observational plots of pasture species and fodder crops have been laid out. The results indicate that intensive management on the natural pasture paddocks leads to an increase in a desirable type of herbage. In the observational plots, the most successful pasture species observed were: *Amphilophis pertusa* Stapf, *Cenchrus ciliaris* Linn. (erect strain), *Chloris gayana* Kunth (Australian strain), *Chloris gayana* (Trans Nzoia strain), *Setaria* sp., *Brachiaria brizantha* Stapf, and *Melinis minutiflora* P. Beauv. Little success has been obtained from pasture legumes, apart from some promise given by lucerne and Hubam clover as fodder crops.

At Molo, a sub-station situated at 9,200 feet altitude, the work deals mainly with European species, of which the most successful have been *Lolium perenne* and *L. italicum*, *Festuca pratensis* (Danish), *Dactylis glomerata*, *Phalaris tuberosa*, and *Bromus marginatus*. It appears that some of these grasses will be suited for short leys in rotation with wheat in limited areas. Kikuyu grass is, however, the main pasture plant of this area.

RHODES GRASS TRIALS.

So far definite success has been obtained with this grass in areas ranging roughly from 5,000 feet to 8,000 feet with an average annual rainfall of from 25 to 55 inches. Yields of hay at Kabete have averaged approximately three tons per acre and it has been shown that 200 lb. and over of seed per acre can be obtained. Grazing experiments have shown a distinctly higher milk yield from Rhodes grass than from natural pastures; heavily stocked areas of this grass can be used successfully in the dry periods of the year, and may serve to lengthen the period in which grazing can be made available. This species is well suited for use in areas of intermediate climatic conditions and for the production of pasture and hay on disused arable land over large portions of the country.

GRASSLAND WORK IN NATIVE AREAS.

The great pastoral tribes which occupy the regions of erratic rainfall offer the greatest problems. The depletion and often complete removal of the vegetation, chiefly from mismanagement of the grazing, has been accentuated by the limitations of the areas over which these nomadic tribes are able to move.

The Kamba tribe, occupying higher rainfall areas, offers a slightly different problem for it is primarily a stock-owning tribe frequently owning sections of the land. To overcome the difficulties of soil erosion and the widespread deterioration of the grasslands a scheme for the application of a simple method of control of grazing has been drawn up and a committee appointed to apply the scheme.

Among the agricultural tribes the main necessity is to demonstrate on small-holding lines the possibilities of intensive management of pastures. In the high altitude areas these pastures will consist in the majority of cases of *Pennisetum clandestinum* and *Trifolium Johnstonii*, and establishment can be accomplished by methods readily available to the natives. The production of fodder crops for use in dry periods is closely bound up with the possibility of developing the small-holding plan.

The problem of grass burning has been given considerable attention and the findings to date at Ngong are summarized as follows. An accumulation of old growth from season to season results in weakening of the dominant type in the herbage, *Themeda triandra*, an increase in the growth of shrubs, and apparently a thinning of the plant stand in general, with a consequent increase in the proportion of bare ground. The prevention of accumulation of old growth either by grazing or burning appears to have had a similar effect in the opposite direction. *Themeda triandra* has remained strongly dominant, and the growth of shrubby plants has been retarded. The ground cover has improved under the heavier grazing treatments.

* * * * *

In the Kenya Department of Agriculture Annual Report is also the report of the Central Province (W. G. Leckie, Provincial Agricultural Officer), which contains some references of interest.

The loss of soil fertility caused by erosion and prolonged cultivation without manure is regarded as the most serious problem of the moment. The solution is considered to be the small-holding, carrying a few cows in milk and the sending of dry cows and bullocks out to communal grazing areas. Efforts are being made to persuade the natives to lay down steep land unfit for cultivation to permanent grazing, and to plant small areas near the villages to Napier grass.

Plans for the control of erosion include the recommendation for Magnum broad base terracing, bench terracing, the planting of strips of Napier grass along contours, the laying down of steep land to permanent grazing and forest, and the protection of the banks of water courses and gullies.

From two reconditioning experiments it was found that by stagger-trenching and planting to *Cynodon* sp., denuded land can be made capable of supporting stock in two years, but when stagger-trenching alone is adopted it requires three-and-a-half years.

A fodder tree arboretum was established in 1934 to investigate the possibilities of using such plants in the long-range policy for the future reconditioning of reserves. Severe drought conditions have been experienced and the trees which have survived are: *Brachychiton rupestris*, *Phytolacca dioica*, *Disperma trachyphyllus* and *Atriplex nummularia*.

Crop introduction and trials have resulted as follows: of twelve imported varieties of sorghum, Sunrise Kaffir (sweet), and Bonganilo (bitter) have been selected for bulking and distribution in the Kikuyu and Ukamba districts respectively. Muratha, a departmental selection of drought-resistant maize, has proven satisfactory. Tanganyika Awned Bulrush millet has proven very promising and is being distributed to all seed farms. Of the legumes under trial, Tepary bean, Morogoro cowpea, black gram and green gram have all yielded well.

SOIL CONSERVATION SERVICE.

[Reviewer : R. O. WHYTE.]

THE Report of the Chief of the Soil Conservation Service (Mr. H. H. Bennett) for the fiscal year ended June 30, 1936, has been received. The year under review is stated to be one of significant advance towards better husbandry of the nation's soil and water resources. The report is divided into the following chief sections :

- Field operations programme
- Division of conservation operations
- Research programme
- Division of research
- Co-operative relations and planning
- Business management
- Personnel and training.

After introductory remarks on the relative responsibilities of the Federal and State authorities and the relationship of the Service with other Federal agencies, the connexion between soil erosion and flood control and the alleviation of the drought problem, the Report describes the regionalization which took place during the period July to September, 1935. In an effort to decentralize administration and technical supervision, the field organization which had previously been operated on a project basis was divided into eleven administrative regions, each of which conforms as closely as possible with regional problems of soil conservation and land use.



Each of the eleven regions is under the jurisdiction of a regional conservator with headquarters at a point most convenient for transportation, communication and accessibility to projects within the region. Operations and co-operative relations in each State within the region are under the supervision of a State co-ordinator with headquarters generally at or near the State College of Agriculture.

Table 1. Soil conservation regions.

Region No.	Name of region.	Headquarters.	States included.
1	Northeast.	Williamsport, Pa.	West Virginia, Maryland, Pennsylvania, Rhode Island, Delaware, New York, Connecticut, Massachusetts, Vermont, New Hampshire, Maine, New Jersey.
2	Southeast.	Spartanburg, S.C.	Virginia, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Florida.
3	Ohio Valley.	Dayton, Ohio.	Ohio, Michigan, Indiana, Kentucky, Tennessee.
4	Midsouth.	Fort Worth, Tex.	Arkansas, Louisiana, Texas (except Texas Panhandle, which is included in region No. 6).
5	Upper Mississippi.	Des Moines, Iowa.	Minnesota, Wisconsin, Illinois, Iowa, Missouri.
6	Southern Great Plains wind erosion.	Amarillo, Tex.	Texas Panhandle, Oklahoma Panhandle, western Kansas, Colorado east of the Continental Divide, eastern New Mexico.
7	Central Great Plains.	Salina, Kansas.	Nebraska, Kansas (except portion included in region No. 6), Oklahoma (except Oklahoma Panhandle included in region No. 6).
8	Southwest.	Albuquerque, N. Mexico.	Arizona, Utah, Colorado west of the Continental Divide, western New Mexico.
9	Northwest.	Rapid City, S. Dakota.	North Dakota, South Dakota, Wyoming, Montana.
10	Pacific Southwest.	Santa Paula, Calif.	California and Nevada.
11	Pacific Northwest.	Spokane, Wash.	Washington, Oregon, Idaho.

Fullest possible co-operation with State agricultural agencies is maintained through State advisory committees composed of the State co-ordinator of the Soil Conservation Service, the director of extension and the director of the agricultural experiment station. In certain States additional members are appointed to the committee, but in no case does the membership exceed five.

Field operation projects and Emergency Conservation Work camps are under the administrative supervision of the regional conservator through the State co-ordinator. Responsibility for general supervision of field activities rests with the State co-ordinator, who carries out the major operating policies established for the region as a whole. Each field project is under the direction of a project manager and a staff composed of specialists in each phase of agricultural work involved in the co-ordinated programme used by the Service in that locality.

Space does not permit our full consideration of those sections of the Report dealing with the field operations programme. These are essentially demonstrations of erosion control on private lands, but in addition the Service directed extensive erosion-control and land-management programmes on large tracts of federally owned land in the south-west and in Wyoming. These projects are (1) the Navajo Indian Reservation of 17,000,000 acres in New Mexico and Arizona; (2) the upper Gila river watershed including the San Pedro and Santa Cruz tributaries comprising

13,900,000 acres in New Mexico and Arizona ; (3) the Rio Grande watershed above Elephant Butte Reservoir, embracing 14,300,000 acres in New Mexico ; (4) the entire Shoshone Indian Reservation of 2,400,000 acres in Wyoming. This last mentioned project has been newly established.

In co-operation with the Indian Service, material progress was recorded in the development of sound land-use programmes permitting the users of Indian land to carry on operations without shifts.

During the first part of the fiscal year, work on the Gila River project was directed primarily towards gully control and the construction of stock watering tanks. Water spreading and range revegetation are now a major phase of the operations, the primary objectives of which are : (1) to effectuate sound, regulated, grazing practices ; (2) to reduce as far as possible the rapid rate of sheet and gully erosion by mechanical methods ; (3) to promote the growth of vegetation by all adaptable means and measures, particularly as regards the retention and surface distribution of excess rainfall.

Range-land management represents the most important problem of the Navajo project area. Agricultural and grazing surveys have been made on a wide area and operations will be planned for complete treatment of important regions in co-operation with the Indian Service, the Forest Service, and the Taylor Grazing Act administration.

On the Rio Grande project area, the chief causes of erosion are overgrazing, improper selection of land for farming uses, failure to protect crop residues during dry winter seasons, neglect of roads, trails, and abandoned land, and improper tillage methods.

During the year the Rio Grande district organization instituted a number of surveys in co-operation with the United Pueblos. Results will serve for defining policies and plans to alleviate erosion conditions and to assist the Indians to become as self-sustaining as possible with resources at hand.

The solution of range-land erosion lies in the field of regulating grazing practices and rehabilitating the range to native grasses. Arroyo treatment and river bank protection are essential to prevent undercutting by meandering currents. Detention dams, diversion ditches, and range terraces have been constructed to assist the work of impounding run-off waters in arroyos and diverting some of them to revegetated areas.

The Report of the Division of Conservation Operations discusses erosion control practices, conservation surveys, agronomy, nurseries, engineering, woodland and wild-life management.

A detailed survey of 20 counties in the southern Great Plains is reviewed elsewhere in this issue of *Herbage Reviews*. A survey of Puerto Rico has been made and the results prepared for publication. Field work was completed on an extension of the southern Great Plains survey to cover 19,000 square miles in eastern New Mexico. A reconnaissance survey of 6,500 square miles in North Dakota was about half completed at the close of the year under review.

The agronomic operations of the Service form an important part of the programme of erosion control on farm fields and pastures, which is carried on in close co-operation with agronomists of the State experiment stations and the Federal Extension Service, the Bureau of Plant Industry, the Forest Service, the Bureau of Animal Industry, and other agencies of the U.S. Department of Agriculture.

Control of erosion involves the proper use of rotations and best farming methods, the practices of strip cropping, contour farming, and proper tillage methods ; the proper management of pastures, including controlled and rotational grazing, reduction in livestock, the establishment of supplementary pastures, the use of contour furrows, and the re-seeding of a large acreage of erodible land removed from cultivation. It was possible for the Service during the year under review to put into use on

a large scale practices recommended by the State experiment stations, including in particular crop rotations, adapted crop varieties, the fertilization and management of pastures, and the use of supplementary pastures.

The Section of Conservation Nurseries is primarily concerned with providing suitable planting materials for use in the various phases of erosion control and general revegetation. Its major work includes the production of nursery stock and the collection of native seeds and plants in quantity, as well as technical supervision in procuring commercial seeds, fertilizers, etc. Specialized activities include :

- (1) Assembling and observing plants which may be of greater value in erosion control than those now used.
- (2) Collecting small lots of seed for inter-regional exchange and test.
- (3) Making seed germination and treatment tests.
- (4) Working out appropriate, practical methods of propagation.
- (5) Developing special methods and machinery for harvesting native seeds.

Forty-eight major nurseries are now operated by the Service.

A balanced programme of research has been carried on by the Service in co-operation with the State Agricultural Experiment Stations and in certain instances with other organizations such as universities, research institutions, State water boards and the National Research Council.

The Division of Research is organized into six closely co-ordinated sub-divisions. These are concerned respectively with soil erosion and moisture conservation studies, watershed studies, sedimentation and hydrologic studies, climatic and physiographic studies, hill culture studies, and economics and soil conservation.

The official organ of the Service, *Soil Conservation*, was published throughout the year (eleven issues). This Journal is intended to provide administrative information and news of the Service activities, to act as a clearing house for ideas, experiences and discoveries, and to constitute a convenient record of the current history of the Service. Throughout the year the demand for the magazine greatly exceeded the supply, and future issues will be increased as regards number of pages and copies. The editor's address is as follows :

Editor of *Soil Conservation*,
Soil Conservation Service,
U.S. Department of Agriculture,
Washington, D.C.,
U.S.A.

WIND EROSION IN THE SOUTHERN GREAT PLAINS.

[Reviewer : R. M. WHYTE.]

A BULLETIN by A. H. Joel, Western Field Office, Section of Conservation Surveys, Soil Conservation Service, discusses the erosion problem as it affects the Southern Great Plains of the U.S.A.* The data included in this report were collected by thirty-five Soil Conservation Surveyors at the request of the Resettlement Administration. The survey covers twenty counties situated in southeastern Colorado, southwestern Kansas, and the Panhandle areas of Texas and Oklahoma with an area of approximately 25,000 square miles.

The author commences with an account of the seriousness of erosion, particularly wind, in this area. It has resulted in a great increase of respiratory diseases, extensive damage to property and has made travel difficult. In addition, the intensity of dust storms as determined by visibility observations is stressed. Finally, the fact that dust travels considerable distances has brought this wind-erosion area into the forefront of national problems.

This survey classifies erosion conditions as affected by degree of slope, land utilization, vegetative cover and general character of slopes. A map indicates the position of the surveyed area in relation to the Southern short grass plains.

Climate has had a very important influence on the various problems which have arisen. It is essentially of the semi-arid to sub-humid, temperate, continental type. The area is characterized by limited precipitation of irregular seasonal distribution, high evaporation rate, low relative humidity, high average wind velocity, a considerable diurnal temperature range and a considerable amount of the precipitation falling as torrential rains with consequent severe run-off on certain 'hard' lands. Topographically, the area is an extensive plain at an average elevation of 3,000 to 4,000 feet with a gently sloping, smooth surface interrupted by "breaks" or rougher lands along the main river courses.

The slope ranges chosen for the purpose of this survey were selected because of their close relationship to erosion, erosion-control practices and moisture conservation. The author gives considerable detail of the extent of each slope in each county. The distribution of the slope ranges in the whole area is : (1) 59.2 per cent on a 0 to 2 per cent slope ; (2) 28 per cent, 2 to 5 per cent slope ; (3) 7.1 per cent, 5 to 10 per cent and (4) 5.7 per cent over 10 per cent slope. The occurrence of large areas of almost flat land decreases the possibility of extensive water erosion, but this lack of topographic relief and forest cover over large areas allows winds to sweep unobstructed, thus producing "black blizzards" of startling proportions.

The dominant native vegetation of the area is buffalo grass (*Buchloë dactyloides*) with some blue grama (*Bouteloua gracilis*), both low-growing shallow rooted plants. On the more porous and uneven sandy soils, taller plants such as *Aristida* spp., *Andropogon scoparius*, *Artemisia filifolia*, and *Yucca* often dominate the shorter grasses. During recent years overgrazing, drought and consequent wind erosion have resulted in serious depletion of the native vegetation. Considerable areas have less than 50 per cent of the normal vegetative cover, with smaller areas having only 25 per cent cover. On many ranges the carrying capacity is far below normal while others are too small to allow effective controlled grazing and satisfactory economic returns. This situation suggests that any programme for this area must take into account land reorganization and land-use readjustment.

*UNITED STATES Department of Agriculture, Soil Conservation Service. Tech. Bull. No. 556. Soil conservation reconnaissance survey of the Southern Great Plains wind erosion area. By A. H. Joel. Washington, 1937. pp. 68.

The soils of the area are of pedocalic development with a neutral or basic reaction. Large sections of the area have soils derived from similar parent material; consequently there are extensive areas with similar erosion susceptibility and agricultural adaptation. The soils are divided into nine main types which are further classified into five groups dependent on the textural character of the soil. Details of the nine soil types are included. The main settlement in the area has taken place since the World War and it is interesting to observe that during the very dry years 1893-5 when the region was sparsely populated there was very little, if any, wind erosion, whereas in recent years drought combined with serious erosion has led to crop failures year after year.

Of the total area under consideration 40.5 per cent is cultivated land, 8.5 per cent idle and 51 per cent pasture. Dry farming of wheat and livestock production form the chief agricultural economy of the region. The influence of size of farms and land tenure on erosion conditions is discussed. It is emphasized that in this area all the conditions necessary for wind erosion frequently occur; (1) soil in a condition to blow, (2) frequent strong winds, and (3) insufficient vegetative cover to prevent the soil blowing. Accelerated erosion has affected 96.9 per cent of the area; of this 53.4 per cent has been seriously damaged. The distribution of damage by wind and water is significant in that 68.6 per cent has been affected by wind only and 6.3 per cent by water.

Idle and cultivated land has been more seriously affected than pasture, particularly where the soils are sandy or finely granular in structure. Tables summarize the major classes of erosion in counties as well as the acreage of slope groups. The necessity for further research on the relationship between degree of slope and wind erosion is stressed.

In later sections of the bulletin the writer deals with the remedies and adjustments which are necessary if abandonment of the area is to be avoided. In the first place a complete readjustment of land utilization must be carried out. This will involve complex economic and social problems as well as physical, but is essential before a broad corrective programme can be formulated.

Vegetative protection on the ranges must be increased and should be provided on crop lands too during the critical blow periods. Methods for planting wide row crops for cover only, type of crop most suitable, mechanical aids for moisture conservation are analysed. The superiority of Sudan grass and sorghums as cover crops in this area is stressed. On range land the problem is essentially as important but demands different corrective measures. The first necessity is to increase the native vegetative cover by means of reducing the number of stock, thus reducing the damage caused by overgrazing and trampling. It is suggested that ranges should be enlarged so that they could be run economically. The social problems involved are the most complex and difficult to solve. The total acreage of cultivated and idle land recommended for return to native pasture is over four million acres. The necessity for sacrifices by all classes represented in the area is pointed out.

In an appendix, tabular data relative to dust storms, climate, agricultural statistics and erosion are presented. Separate maps of each county surveyed are stated to be available on application.

MEASUREMENT OF XEROPHYTISM IN SELECTED PASTURE GRASSES*

[Reviewer: M. HALL.]

ABOUT 800 grasses are being tested by the Division of Plant Industry to determine their growing and regenerative capacities under pasturage conditions. The need for developing a method by which the ability of a species to grow in a given habitat can be rapidly measured is emphasized in this study, which is concerned primarily with the establishment of plants in dry areas where ordinary cultural practices are excluded.

The problem is resolved into a consideration of xerophily and the relative extent to which this phenomenon is exhibited by the grass species selected. The amount of reduction which may take place in a plant's water content without detriment to its vital processes is a fixed characteristic. It has been shown by Maximov and Krasnoselsky-Maximov (*J. Ecol.* 12, 95-110, 1924) that the amount of water retained by a plant at the time of wilting is inversely related to the aridity of its natural habitat. Thus extreme xerophytes may lose 50 per cent of their foliar water content before wilting. Water balance of a plant is defined in this work as "the amount of water that a fully turgid plant (or portion of it) has lost on the incidence of wilting, expressed as a percentage of its original content," and water residuum is the amount of water retained by a plant at the incidence of wilting expressed as a percentage of its original content when in a fully turgid state. Evidence is obtained that the magnitude of the water residuum of whole plants is a reliable criterion of their xerophytism.

The method used to determine the onset of wilting is a modification of Bakke's system (*Bot. Gaz.* 60, 314, 1915). This author measured the phenomenon by observing a certain physiological reaction which is expressed as the index of foliar transpiring power, that is, the ratio of the time required for a given quantity of water to evaporate from a standard evaporating surface to the time required for the same amount of water to evaporate from unit leaf area. Using the cobalt chloride paper method (Livingston and Shreve, *Plant World*, 19, 287, 1916) Bakke demonstrated that (1) during the first hour transpiration rate decreased rapidly, (2) for the next four hours it decreased steadily but slowly, but (3) after the fifth hour a marked increase in transpiration rate was apparent for two hours, and finally (4) after the seventh hour the rate decreased steadily as the plants dried. Bakke attributed the change from (1) to (2) to the onset of "temporary wilting" and attributed (3) to a rupture of water columns within the plant and a consequent release of internal tensions. The rupture of the water columns this author considered would follow or coincide with the onset of permanent wilting.

The cobalt chloride method of measuring transpiration rates was found unsuitable for narrow inrolled leaves of grasses. A technique was therefore developed by which the plants were weighed at regular intervals, the difference calculated from any two consecutive weighings being a measure of the average rate of water loss from the plant mass during the time. At the conclusion of each experiment, the plant was dried over calcium chloride until the average loss of weight, per hour, was less than 0.1 per cent of the total water content. The total water content of the fully turgid plant was then calculated by deducting this final weight from the calculated original green weight. The measured water loss during each time interval of any experiment was calculated as a percentage of the total water content to facilitate comparison of the transpirational behaviour of different plants.

*Australia, Council for Scientific and Industrial Research. Bull. No. 102. Studies of selected pasture grasses. The measurement of the xerophytism of any species. By T. B. Paltridge and H. K. C. Mair. Melbourne, 1936. pp. 38.

Data obtained from *Themeda australis* are represented graphically and confirm Bakke's findings (1) and (2), but not (3). An appendix to the present work describes experiments designed to determine whether transpirational behaviour of grasses differs from that of dicotyledons. The results obtained with species of *Lactuca*, *Plantago*, *Polygonum* and *Trifolium* were similar to those of the grasses and it is maintained, on the support of further experimental evidence, that the rate of water loss from the leaves, as measured by the cobalt chloride paper method, is not strictly comparable with the loss of water from the mass of the plant. After a critical examination of the two types of curves obtained by Bakke and in the present work it is concluded that there is no distinction between "temporary" and "permanent" wilting. There is only one type of wilting and it is made evident whenever the total water content is so reduced that the turgor pressure of the cells approaches zero. In the graphs illustrating transpirational behaviour the onset of this wilting is indicated at a point where there is a temporary halt in the normal deceleration, and where the normal decrease in the rate of loss of water as the turgor pressure of the cells decreases is no longer evident. Transpiration rate tends to remain constant for a short time after which some internal change, associated with irreparable damage to the plant, permits a further decrease in the rate. Throughout these experiments this criterion of the incidence of wilting has been used.

It is obvious that age and size of the plants are important factors in relation to the incidence of wilting when estimating the xerophytism of a species by this method. From experiments made it has been observed that the water residuum in any one grass species is practically constant for plants up to 12 months after germination, but there is a marked difference in the time elapsing before the water content of young and old plants reaches a critical level. Data on this aspect obtained from *Festuca mairei* are supplied. It is inferred that the age of a specimen will not affect estimation of its xerophytism although the time required by younger plants to reach a wilted condition is much less than that required by older ones when water supply is inadequate. In determining xerophytism it is advisable to use plants as soon after germination as possible. For the benefit of those who may wish to use the method, important aspects of technique are discussed, namely, the consideration of environmental conditions on the measurement of the water residuum of plants and the magnitude of the error introduced by using longer time intervals in plotting graphs.

Results. The studies so far completed have included experiments with seventeen grasses. The estimation of xerophytism is shown diagrammatically and an arbitrary classification adopted is as follows:

1. Mesophytes. Plants that wilt before losing 50 per cent of their total water content.
 - A. True Mesophytes. Water residuum 75 per cent. No grass placed in this group.
 - B. Xerophytic Mesophytes. Water residuum 50 to 75 per cent. *Brachypodium phoenicoides*, *Festuca mairei*, *Lolium perenne*, *Bromus macrostachys*, *B. brizaeformis*, *Themeda australis* and *Festuca rubra*.
2. Xerophytes. Plants that wilt only after losing more than 50 per cent of their total water content.
 - C. Mesophytic Xerophytes. Water residuum 25 to 50 per cent. *Eragrostis virescens*, *Danthonia semiannularis* and *D. Richardsoni*.
 - D. True Xerophytes. Water residuum 25 per cent. *Agropyron intermedium*, *Phalaris stenoptera*, *Agropyron cristatum*, *Phalaris coerulescens*, *Ehrharta erecta*, *Oryzopsis miliacea* and *Stipa nitida*.

An analysis of the figures for all experiments used in compiling the above data shows that at the time of wilting the average transpiration rate (expressed as a percentage of the total water content) for B is 16 per cent per hour, for C, 7 per cent per hour and for D, 4 per cent per hour. The water loss per unit time interval (transpiration rate) at the time of wilting, expressed as a percentage of the amount of water lost during the first time interval of any experiment for B is 52 per cent ± 3.1 , for C, 14 per cent ± 2.6 and for D, 7 per cent ± 1.4 . The experiments suggest that transpiration rate at the time of wilting may diminish in accordance with the greater xerophytism of the species.

A notable result of the study is the discovery that xerophytic grasses lose more than 75 per cent of their total water content before the onset of the critical wilted condition. Such extreme desiccation prior to wilting is not an unusual phenomenon.

The first appendix to the paper supplies notes on the distribution of grasses studied, given as an index of the aridity of their natural environment. This confirms that the relative xerophytism of the different species as determined from experimental data is in accordance with the relative aridity of their natural habitats and supports the theoretical considerations which suggest that the water residuum of whole plants is a reliable criterion of their xerophytism.

Note.—The report of the Waite Agricultural Research Institute, Glen Osmond, South Australia, 1933-6, which contains a section on the water requirements of pasture plants, will be reviewed in *Herb. Rev.* 5, No. 3, 1937.

ANNOTATIONS

GREAT BRITAIN.

(410)

The Herbage Bureau has been supplied with seed of the following species from the U.S. Department of Agriculture through Mr. H. C. Sampson, Economic Botanist, Royal Botanic Gardens, Kew.

Agropyron cristatum.
Bouteloua curtipendula.
„ *gracilis.*
Buchloë dactyloides.
Lespedeza bicolor Turcz. 22323.
„ *sericea* 19284.
„ *stipulacea.*
„ *striata.*
„ *striata* var. Kobe.

Any investigators wishing to test any of these species are requested to communicate immediately with the Chief Officer, stating their minimum requirements as to amount of seed. Soil can be supplied with the seed of the *Lespedeza* species for inoculation purposes.

CZECHOSLOVAKIA.

(437)

Second All-State Course for Forage Plant Production.

A publication has been produced by the Union of Agricultural Experiment Stations, Prague, under the editorship of M. Maloch (pp. 89, 1936); it contains lectures presented at the second course on forage crop production organized by the Forage Crop Commission of the Czechoslovak Union of Agricultural Experiment Stations in Subcarpathian Ruthenia, and in addition a description of the excursions.

In the introduction, A. Klečka stresses the importance of the forage crop courses. V. Ščerecký explains the main tasks of forage production in the lowlands and highlands of Ruthenia, such as the promotion of ensilage, the establishment of a Station for mountain seed production at Svalava, etc. J. Hruza deals with water regulation of Černý Močál (Black Swamp), the agricultural description of which is given by F. Charvát. J. Dubec discusses the application of liquid manure, and R. Jordan presents a general picture of the technical and administrative regulations for improvement of polonins and forests. P. Miláček deals with the practical application of different methods for improvement of polonins.

Several of the other articles are abstracted separately below.

A. MARGITTAI. Black swamp. (pp. 12-14.)

The drainage of Čierny Močiar destroyed the original interesting swamp fauna and flora; remnants still survive on parts where drainage was ineffective. The creation of a reservation is proposed. Rare plants include *Beckmannia eruciformis* and other species.

F. CHARVÁT. Forage crop cultivation in the lowlands of the River Tisa (pp. 24-32.)

High insolation, evaporation, annual rainfall of 700 to 800 mm. and fertile soil favour the production of a great variety of forage crops in this area, but the low standard of agriculture causes yields to be lower than in other parts of Czechoslovakia. Statistics are furnished regarding acreages under different forage crops (clover, lucerne, sainfoin and mixtures).

J. KOUDELKA. The pasture farm at Orosijevo in Subcarpathian Ruthenia (pp. 33-36).

This farm, 28 ha. in area, was established for raising and pasturing one and two-year-old foals. After draining and fertilizing, the entire area was sown with a grass mixture recommended by the Forage Crop Station, Rožnov. Irrigation is to be arranged in 1937.

J. RAJEVSKÝ. Production and cleaning of red clover seed in the Sevluš district (pp. 37-39).

Until 1914, red clover was grown on the larger farms only, but during the war even that small amount was abandoned. After 1920 seed was introduced from Moravia and Bohemia and production recommended. To improve the seed quality, a cleaning station was erected at Sevlus, where conditions are particularly favourable for ripening. The cleaning of seed not only reduced the percentage of dodder in clover fields, but also caused an increase of 40 per cent in total area and a higher yield, so that seed is now exported.

M. MALOCH. Improvement of polonins in Subcarpathian Ruthenia from the research aspect (pp. 53-8).

A young Nardetum furnishes a pasture containing over 6 per cent digestible protein in the Carpathian mountains, but it contains more than 1 per cent silica. During ripening, the fibre content rises from 25 to 40 per cent. By manuring, fertilizing, resowing and controlled grazing, each of which is described in detail, the nitrogen content is increased and that of silica and fibre reduced.

R. ADÁMEK. Methods of improving farming in Vrchovina (mountainous parts of Subcarpathian Ruthenia). (pp. 59-65.)

The results of activities of the Experiment Station at Nižní Verecký on fields 470 to 650 m. above sea level are reported. From 1927 to 1935, yields per hectare were increased as follows: forage beet from 228 q. to 810 q.; permanent meadow hay from 13 to 36.6 q.; clover-grass mixture from 16.9 q. to 79.9 q.; maize for ensilage from 189 q. to 546.6 q.

As forage beet may yield up to 1100 q. per hectare, it is considered to be the best forage crop. The best mixtures were red + white clover, red clover + *Phleum pratense*, red clover + *Arrhenatherum elatius*, red clover + *Lolium perenne*. After five years, the most widely distributed and adapted genera in grass mixtures are *Arrhenatherum*, *Trisetum*, *Cynosurus*, *Dactylis*, *Poa pratensis* and *P. fertilis*.

M. MALOCH. Cleaning bushes from polonins in the light of agrobotanical studies (pp. 65-71).

Results are presented of studies on Černá Hora and Svidovec polonins. The burning of *Juniperus nana* and *Alnus viridis* alone does not improve the composition of the turf. Actually the grass growth in thin stands of *Alnus* is more valuable than that in the open.

A. HILITZER. Protection of vegetation of polonins. (pp. 85-8).

From a phytogeographic point of view, the subalpine and alpine belt in the Carpathian mountains deserves to be protected in some localities. Fifteen areas are described which should be made into reservations. The improvement of the remaining grassland would compensate fully for the slight reduction of the pasture area caused by protected reservation.—F.C.H.

FRANCE.

(44)

Brief reports on the work of the French Government Research Stations and Laboratories are presented in the organ of these Stations, *Ann. Epiphyt. Phytogénét.* 2. 381-422. 1936. The following information relating to herbage and forage crops is included.

Medicago. At Versailles, Colmar and Clermont-Ferrand variety trials have demonstrated the superiority of European over foreign lucernes in regard to productivity, winter hardiness, and immunity to disease. Of the European lucernes, French and Hungarian strains give the best and most uniform results. A population selected at Ormelong, in the Department of Seine-et-Oise, has for four years proved superior to any other lucerne in productivity, earliness, and resistance to disease. Selection is in progress at Versailles and Colmar [see *Herb. Abstr.* 5. 228. 1935, and *Herb. Rev.* 4. 24-5. 1936].

Trifolium pratense. In variety trials at the three above-mentioned stations, French red clovers have proved superior to Italian and American varieties. A Polish variety has given good results at Versailles. Of the French varieties those from Brittany, Normandy and Alsace seem the best.

In the Phytopathological Laboratory *Gloeosporium caulivorum* Kirchner, parasitic on a clover emanating from Italy, has been isolated; and the following fungi are recorded for lucerne, *Fusarium avenaceum* (Fr.) Sacc., *F. orthoceras* App. et Wr., and *Sclerotinia Trifoliorum* Eriksson.

Halo blight of beans. Seventeen bacterial cultures have been isolated from spots on leaves and pods, two of which have proved pathogenic. Both differ from *Pseudomonas medicaginis* var. *phaseolicola*.

Disease of *Pisum*. The following parasites are recorded for the Sarcelles experiment fields: *Cylindrocarpon Ehrenbergi* Wollenweber; *Ascochyta pisi* Lib., *Peronospora Pisi* (de Bary), Sydow., *Thielaviopsis basicola* (Berk.) Ferraris. Five *Fusarium* species and *Ascochyta pisi* Lib. were isolated from peas in 1934 and 1935. Inoculation experiments are briefly described.

Diseased golf green. *Fusarium nivale* (Fr.) Ces., *Hainesia* sp. and *Pythium* sp. have been isolated from diseased turves, the two last named fungi proving pathogenic on several grasses (listed).—G.M.R.

* * * * *

The death of H. de Guerpel is announced (*Rev. Bot. appl.* 17. 195. 1937). Monsieur de Guerpel will be remembered for his work on the acclimatization of the soybean in Normandy. [See *Herb. Abstr.* 5. 66 and 232. 1935.]

U.S.S.R.

(47)

The Azov—Black Sea Plant Breeding Centre.

The activities of this Centre are described by I. N. Kovalev and M. F. Ternovskii in *Trudy Azovo-Černomorskogo Selekcendra* No. 1, 1936. The Centre was opened in 1934 on the basis of the Kuban Agricultural Station which was founded in 1912. It is

situated near Krasnodar on a flat plain 40 m. above sea level where the heavy leaching black soil contains 3 per cent humus; the humus layer is about 150 to 200 cm. thick; the parent material is a heavy loess loam. The climatic conditions, which include 600 mm. annual rainfall and 10 to 11°C. annual mean temperature, can be regarded as typical for the whole Kuban Valley. The Centre owns about 2286 ha.

At the present time it comprises the following departments:

- (1) Department of Plant Breeding, including section of grain crops, forage crops, cytogenetics, physiology, phyto-entomology and technology.
- (2) Department of Seed Production, including section of varietal tests.
- (3) Department of Agrotechnique.
- (4) Department of Biochemistry.
- (5) Bureau of Agricultural Propaganda and Publication.

Department of Plant Breeding. The section of forage plants (Professor V. S. Bogdan) deals chiefly with various lucernes, sainfoins and Sudan grass, but some other plants such as *Trifolium*, *Festuca*, *Bromus* and *Dactylis* have also been studied. In addition to lucerne and sainfoin, *Lotus corniculatus* and *Bromus inermis*, and to a less extent *Festuca arundinacea* and *Avena elatior* (*Arrhenatherum elatius*) are promising in this region. Some valuable forms have been selected from these species and from *Festuca pratensis* and *Lolium italicum*. The varietal study of Sudan grass has indicated a number of valuable forms to which individual attention is being given.

Section of Cytogenetics (V. A. Hižnjak) deals with inter-specific hybridization and with *Agropyron* × *Triticum* hybrids, particular attention being devoted to the latter. At the present time 4,500 clones of the first generation (130 combinations) and 1,000 clones of the second generation are being studied. The fact that the hybrids differ in a number of characters is thought to be due to the extreme heterozygosity of *Agropyron*. Some of the hybrids either do not ear in the first year or die at an early stage, but others survive and ear in the first year, giving vigorous tillering and a large number of ears. Reduction division is irregular, only a few chromosomes conjugating and separating irregularly in the anaphase of the heterotypic and homotypic divisions; pollen is abortive, but the female gametophyte is partially fertile.

Section of Physiology (N. E. Kovalevskii) is mainly engaged in the study of the vegetative period, winter hardiness, resistance to drought and immunity. A simplified method of detecting dead tissues of plants by vital staining has been elucidated for evaluating cereals in respect of their winter hardiness; for the same purpose the dynamics of carbon during the winter and the difference in accumulation of sugars in plants which wintered under different conditions were studied. Much attention was given to the vernalization of cereals. Some short-day forms of *Phaseolus* were found to respond readily to darkness. Wilting of plants was studied as a method of estimating their response to drought resistance. Finally, a positive correlation between manurial treatment, size of nutrition area and accumulation of nectar in lucerne was established.

Section of Phyto-entomology (A. D. Kostylev) studied among other items, questions relating to seed setting in lucerne. It was found that the honey bee is unable to effect pollination, which results solely from the activity of some of the wild forms of *Eucera* and *Adrena*, and that when the florets are artificially opened (without introducing foreign pollen) lucerne will set seed. The methods of checking *Adelphocoris lincolatus* and *Poeciloscyltus cognatus* in damaging the seed yields of lucerne were also studied and periods when the pest is least widespread were established; this will enable lucerne plants to escape the pest when their flowering season is appropriately timed by various methods.

Department of Seed Production (N. I. Mironov), occupying some 1588 ha., is engaged in first and second reproductions and in the organization of *élite* reproduction in private farms.

Department of Agrotechnique (A. F. Kazanok) studies the technique of cultivating perennial (lucerne and sainfoin) and annual (Sudan grass, vetch, mohar, sorghum, sweet clover, soybean, maize, etc.) crops and the relative productivity of various crops of possible value in the region. The suitability of "after-harvest" cultivation of Sudan grass and sorghum was ascertained. Maize and soybean in this type of cultivation also gave a high forage yield; a number of annual plants also gave a satisfactory yield, legumes and flax outyielding the others.

Department of Agrobiochemistry, in studying chiefly nutritive content, deals mainly with cereals, soybean and sorghum.—M.A.O.

SWEDEN.

(485)

At a special meeting in Stockholm on February 16, it was decided that on January 1, 1939, the Swedish Grassland Society should be amalgamated with the Swedish Society for the Cultivation of Peatland.—R.P.J.

HOLLAND.

(492)

Government Seed Control Station, Wageningen.

The Short Report of this Station for the year 1935-36 (Kort Verslag v. h. Rijksproefstation v. Zaadcontrôle te Wageningen, 's-Gravenhage, 1936), records a steady increase in the receipt of samples of all grass species. Grass and clover seed composed 1,427 of the samples received by the Station, the total number of which has again increased, in the year under review by 10 per cent. The maximum, minimum and mean figures for purity, germination capacity and agricultural value are given for the various kinds of seed, and for moisture content in the case of some species. Of legume samples tested for *Cuscuta* content, not more than 8 per cent contained dodder, and in these not more than 5 per cent of ripe *Cuscuta* seeds were found in any one sample. Of 35 samples of *Trifolium pratense* examined for source of origin, two were found to be adulterated by American seed. Grass seed samples found to contain impurities (small percentages only, and for the most part innocuous) are listed. Ergot, from 0.2 to 1 per cent, is recorded for 24 samples of *Agrostis*, and attack by *Oligotrophus alopecuri*, from 0.1 to 6.6 per cent, is reported in each of the eleven samples of *Alopecurus* tested. Three samples of sweet lupins examined for the presence of bitter lupins were all found to contain a small percentage. In the peas tested a high degree of freedom from *Ascochyta* is reported; and infection by *Macrosporium* and *Botrytis* was absent or present to a small extent only. Marsh spot was exceptional, and in only one case was it serious ($\pm$ 50 per cent). No damage due to *Bruchus* was found in peas, and the field peas were practically free from bacterial disease. Of the field bean samples, 84 per cent were damaged by *Bruchus*, and in some cases living beetles were found.

Netherlands Department of Agriculture.

In a report on the economic position of agriculture in the Netherlands in the year 1935-36 (*Versl. Med. Dir. Landbouww. 1937. No. 1*), attention is drawn to the improvement which has taken place in grassland farming, the net profit of 4.05 florins per hectare recorded for the previous year having risen to 23.55 florins per hectare. In the case of the dairy farms this is attributed to the higher prices obtained for milk (p. 17). In another section of the report, however, a reduction in the amount spent on animal feed during the year under review is noted. While this is due in part to a fall in the prices of the principal feeding stuffs and to the holding of less stock, on the other hand there has been an improvement in grazing technique and in the amount of home-grown fodder produced, together with an extension of the practice of ensilage (p. 26).

The N.A.K. (Netherlands General Inspection Service).

This Service inspects seed crops in the field and certifies seed and seed potatoes that reach the required standard. In the report for the year 1935-36 (*Vierde jaarverslag van de Nederlandsche Algemeene Keuringsdienst, Wageningen, 1936*) the following figures are given for herbage plants. Grasses: crops inspected, 40, occupying 125.45 hectares; passed as satisfactory, 26, occupying 111.57 hectares; rejected, 14, occupying 13.88 hectares. The rejected crops consisted of *Lolium perenne* and *Festuca pratensis*. On the other hand 16 crops of *Lolium perenne*, or 42.50 hectares, were passed. Clovers: crops inspected, 290, occupying 161.76 hectares; passed as satisfactory, 283, or 152.88 hectares; rejected, 7 (*Trifolium pratense*, 1; *T. repens*, 6).—G.M.R.

U.S.S.R. SIBERIA.

(57)

Kamchatka Agricultural Experiment Station.

The work at this station is described by A. V. Mamin in *Bull. Vsesojuz. Akad. Sel'sk Khoz. Nauk. 1936. No. 11, pp. 34-5*. The daily mean temperature is above freezing point from April 7 to October 27, above 5°C. from May 12 to October 12, and above 10°C. from May 23 to September 6. The number of frost-free days varies from 45 to 58. The long day (which compensates for deficient heat in some plants), high air humidity, frequent dews in the dry season and plentiful rainfall in the second half of summer favour cultivation of many crops, although night frosts, frequent even in mid-summer, are dangerous for sensitive crops.

The fodder barley varieties "Červonec" and "Pioner" were superior in fodder and grain yield to those tested hitherto. Spring vetches produced a high forage yield, but did not ripen seeds. A Ural variety of *Trifolium pratense* and *Agropyron tenerum* ripened seeds and produced a high forage yield.—M.A.O.

BRAZIL.

(81)

An address presented by Dr. P. L. de Corrêa, President of the São Paulo Delegation to the Second National Conference on Animal Industry, held at Rio de Janeiro in July, 1936, is published in *Rev. Industr. anim. 3. 7-46. 1936*, under

the title "Aspects of animal production in the State of São Paulo." In dealing with the question of nutrition (pp. 9-15), the author contends that the improvement of stock is subordinate to the improvement of fodder: without the latter good races degenerate and breeding work remains stationary, and it is to poor nutrition that most of the failures to acclimatize good races or to produce successful hybrids must be attributed. The problem is discussed in relation to the State of São Paulo. With the exception of certain hinterland regions in which the ordinary cattle of the country are fattened, the natural grasslands of the State are poor in floristic and chemical composition and are largely superseded by artificial meadows sown down on land reclaimed from the forest. In these *Melinis minutiflora* Beauv., *Andropogon rufus*, *Panicum maximum* Jacq., and its variety *gongylodes*, *Chloris gayana* and *Pennisetum clandestinum* furnish satisfying and wholesome fodder for the better class cattle, which must, however, be supplemented in winter and in times of drought by hay, silage and plants which may be conserved, and by the by-products of cotton plantations, etc. The importance of legume hay in this connexion is stressed, notably that obtained from *Medicago sativa*, *Mucuna* and *Vigna sinensis*. Supplementary rations of this kind are unnecessary for the ordinary cattle raised for the chilled beef factories; grazing furnishes the only economic source of fodder for these herds, and it is abundantly supplied in the hinterlands, where fertile soil and floristic composition alike (Leguminosae well represented) are in favour of the grazier.

The State's Department of Animal Industry maintains four Agrostological Experiment Fields in which collections of forage plants are under observation, and in the laboratories of the Department itself the nutritional aspect of the question is being studied.—G.M.R.

CONFERENCES

MOSCOW, 1936.

The fourth session of the Academy of Agricultural Science held in Moscow from December 19 to 27 was devoted to plant and animal breeding and to those questions of general genetics which, since the report delivered by T. D. Lysenko on June 25, 1935, have been the subject of much, and occasionally passionate, discussion in the scientific periodicals of the Soviet Union. The session was opened in the afternoon of December 19; the opening address was given by A. I. Muralov, President of the Academy, who stressed that "the session to be held must bring clarity to a number of disputable questions and give a required and correct trend to further research on breeding and genetics," and that "the questions under discussion should be considered not abstractly or scholastically, but concretely and with reference to the comprehensive practical research which is being carried out" in the Union. Muralov pointed out that the discussion is of particular significance, as in genetics "stagnation and anachronism" had frequently occurred and hampered breeding work. "If it is necessary," Muralov continued, "as a result of our discussion to revise the outlook and old methods, and replace them by new, our scientific workers will not hesitate to do so," bearing in mind that "science is called science because it is not afraid of any fetish, or of lifting a hand against obsolete and old ideas and listens attentively to the voice of experiment and practice."

After the opening address, the session commenced its work; over 700 persons were present and, in some instances, as on December 22 and 23, more than 3,000 attended. The following programme was adopted.

Reports of experimental research on building up new varieties of cultivated plants and new breeds of domestic animals. Each reporter was given 15 minutes. Of 147 reports received, only 50 were chosen for reading, but eventually 72 were accepted. These reports were read during the remaining part of the evening meeting on Dec. 19, during the morning and evening meetings on Dec. 20 and 21, and during the morning meeting on Dec. 22. An agricultural exhibition comprising exhibits, schemes, diagrams, maps, etc., arranged in the buildings of the Academy, materially demonstrated and illustrated the reports delivered.

The main reports on the theoretical questions of genetics and breeding. The hour allowed for each report was later prolonged to 2.5 hours. The first report was delivered during the evening meeting on Dec. 22, by N. I. Vavilov, Vice-President of the Academy and Director of U.S.S.R. Institute of Plant Industry, Leningrad, who emphasized the value of inbreeding, and, defying Lysenko's views on degeneration of pure lines, quoted some examples to illustrate that some well-balanced pure lines of cereals did not degenerate, though they have been known to be in continuous cultivation for some fifty to a hundred years or more. He considered that correctly organized seed production would be more effective, and certainly less risky than the method of intra-varietal crossing suggested by Lysenko, which must be carefully tested before application on a large scale.

On the following day, T. D. Lysenko, Member of the Academy and Adviser to the Institute of Plant Breeding and Genetics, Odessa, delivered his report in which he emphasized that the difference between the orthodox geneticists and himself is

caused by a discrepancy in outlook on the fundamental principles of evolution, and he accused his opponents of misunderstanding and perverting true Darwinism. Proceeding from his hypothesis, he maintained that the germ-cells as a whole, and not only genes localized in the chromosomes, are the physical basis of heredity, and that the germ-cells, being an inseparable part of the organism, must accumulate and retain all those changes which the organism as affected by the environment, undergoes in its development. He called attention to two cases, namely, degeneration and deterioration of pure lines during long cultivation, as a result of perpetual self-pollination, and the change in the nature of plants in a desired direction by systematic growing in a specially selected environment. He considered that degeneration is caused by narrowing the range of adaptability of the genotype, as the male and female-germ cells developing in the same floret, or in the same plant, are similarly modified by the environment, and thus contribute the same potentialities to the zygote. This degeneration could be prevented by systematic crossing within a line; in cross-pollination the gametes developing in relatively different environments are differently modified, and will thus enlarge the adaptability of the zygote. He supported this view by quoting results of the experiments carried out under his direction in various parts of the Union, in which the Odessa research staff and also ten thousand farmers took part. He reported also the possibility of altering the genotype of plants in a desired direction by systematic growing in a specially selected environment, and exemplified this by quoting results of his experiments on converting winter plants into spring and, conversely, spring plants into winter by forcing these plants to pass through their first developmental stage under conditions differing from those which they would naturally require. He referred to this method as "training" plants, and claimed that, in his experiments with winter cereals, the F_3 plants behaved as typical spring forms and that this conversion was associated with some changes in morphological characters.

A. S. Serebrovskii, Member of the Academy and Scientific Adviser to the U.S.S.R. Institute of Animal Breeding, Moscow, and Prof. H. J. Müller, of Texas University, in their respective reports, defied Lysenko's conception by stressing the existence of the gene, its independence of any part of the organism, and its relative stability; mutations are rare and sporadic and they cannot be directed, as maintained by some investigators, including Lysenko, whose claims are based upon erroneous or insufficiently accurate experimental methods. Finally, they stressed the importance of discriminating between genotype and phenotype, and the relative independence of the former from the latter.

Discussions on the reports were begun on Dec. 25 and concluded on Dec. 27. Over 100 persons reported for discussion; 42 persons expressed their views and discussion was discontinued. No meeting was held on the afternoon of Dec. 23, or on the whole day of Dec. 24.

After the discussions, time was granted to Müller, Serebrovskii, Lysenko and Vavilov for answering their opponents; finally G. K. Meister, Member of the Academy and Scientific Adviser and Director of the Saratov Experiment Station, read a report in which the results of the discussion held on theoretical questions of genetics and breeding were drawn up. He warned research workers that by Darwinism they should understand those conceptions of Darwin which had stood the test and were modified by modern science, but not the original ideas, some of which proved to be erroneous. He considered that Müller and Serebrovskii took a prejudiced position towards Lysenko, and while attempting to defy Lysenko's conceptions they unnecessarily exaggerated the conceptions of gene stability and the impossibility of directing gene mutations. He reminded his audience that Morgan did not deny certain complications in the evolution of the gene, though there are not yet

experimental data to substantiate this possibility. Müller and Serebrovskii overlooked the fact that genetical studies concerned mainly morphological factors; physiological aspects received little consideration in these studies, while their importance, as shown by Bauer, must not be undervalued. Vavilov, in his report, seemed to have overlooked the aim of the present meeting, for instead of a critical review of his research, he spent the time in enumerating advances made at his institutions. The theory of homologous series and of the primary centres had served its purpose by revealing the regularity observed in variability in main morphological characters, but these theories must be revised to eliminate some of the incorrect and fallacious ideas which are contradictory to Darwinism. Turning his attention to Lysenko's report, Meister stressed the importance of some of his researches which had revolutionized science, but he warned Lysenko against some points of his criticism of genetics, such as stability of pure lines or value of inbreeding. The results reported by Lysenko on the training of plants cannot yet be satisfactorily explained in terms of genetics.

The session closed with a concluding address delivered by Muralov.—P.C.K. and M.A.O.

[A mimeographed review of this December Session will be available later from this Bureau, price 2/6. No free copies can be distributed to persons other than official correspondents in British Dominions and Colonies. Orders should be sent as soon as possible, as supplies will be limited.]

- Agropyron*, II4
 A. cristatum, IO9, III
 A. intermedium, IO9
 A. tenerum, II6
Agrostis, II5
Alchemilla, 79, 80, 81, 82
 A. pastoralis, 79
Alnus, II2
 A. viridis, II2
Alopecurus, II5
Amphilophis
 A. pertusa, 98, IO9
Andropogon
 A. rufus, II6
 A. scoparius, IO6
Antennaria, 79, 81, 82
Aristida, IO6
Arrhenatherum, II2
 A. elatius, II2, II4
Artemisia
 A. filifolia, IO6
Atriplex
 A. numularia, IOI
Avena
 A. elatior, II4

Beckmannia
 B. eruciformis, II2
Bouteloua
 B. curtipendula, III
 B. gracilis, IO6, III
Brachiaria
 B. brizantha, 99, IOO
Brachychiton
 B. rupestra, IOI
Brachypodium
 B. phoenicoides, IO9
Bromus, II4
 B. brizaeformis, IO9
 B. inermis, II4
 B. macrostachys, IO9
 B. marginatus, IOO
Buchloë
 B. dactyloides, IO6, III

Cenchrus
 C. ciliaris, IOO
Chloris
 C. gayana, 98, 99, IOO, II7
Cirsium
 C. palustre, 80
Cuscuta, II5
Cynodon, IOI
 C. plectostachyum, 99
Cynosurus, II2

Dactylis, II2, II4
 D. glomerata, 91, 93, IOO
Danthonia
 D. Richardsoni, IO9
 D. semiannularis, IO9
Deschampsia
 D. flexuosa, 79
Digitaria
 D. scalarum, 99
Disperma
 D. trachyphyllus, IOI

Ehrharta
 E. erecta, IO9
Eragrostis
 E. tenuifolia, 99
 E. virescens, IO9

Festuca, II4
 F. arundinacea, II4
 F. mairei, IO9
 F. ovina, 79
 F. pratensis, IOO, II4, II6
 F. rubra, 91, 92, 93, IO9

Galium
 G. uliginosum, 80

Hyparrhenia
 H. filipendula, 99
 H. Ruprechtii, 99

Indigofera
 I. tectensis, 98

Juniperus
 J. nana, II2

Knautia
 K. arvensis, 80

Lactuca, IO9
Lespedeza, 98
 L. bicolor, III
 L. sericea, III
 L. stipulacea, III
 L. striata, III
Lolium
 L. italicum, IOO, II4
 L. perenne, IOO, IO9, II2, II6

*Lotus**L. corniculatus*, 114*Medicago*, 113*M. falcata*, 87*M. media*, 87*M. sativa*, 87, 117*Melinis**M. minutifolia*, 99, 100, 117*Mucuna*, 117*Nardus*, 79, 81, 82*Olea**O. cuspidata*, 75*Oryzopsis**O. miliacea*, 109*Panicum**P. maximum*, 117*P. trichocladum*, 100*Paspalum**P. dilatatum*, 99*Pennisetum*, 100*P. clandestinum*, 98, 99, 101, 117*P. Schimperii*, 100*Phalaris**P. coerulea*, 109*P. stenoptera*, 109*P. tuberosa*, 100*Phaseolus*, 114*Phleum**P. pratense*, 91, 93, 112*Phytolacca**P. dioica*, 101*Pisum*, 113*Plantago*, 109*Pleurozium**P. Schreberi*, 79*Poa**P. fertilis*, 112*P. pratensis*, 91, 92, 93, 112*Polygonum*, 109*Quercus**Q. dilatata*, 75*Q. ilex*, 75*Q. incana*, 75*Q. semicarpifolia*, 75*Rhytidiadelphus**R. squarrosus*, 79*Setaria*, 100*Sorghum**S. durra*, 74*Stipa**S. nitida*, 109*Themeda**T. australis*, 109*T. triandra*, 99, 100, 101*Thuidium**T. abietinum*, 79*Trichopteryx**T. kagerensis*, 99*Trifolium*, 109, 114*T. alexandrinum*, 74*T. Johnstonii*, 98, 101*T. pratense*, 80, 113, 115, 116*T. repens*, 116*T. resupinatum*, 74*T. spadiceum*, 80*Trisetum*, 112*Triticum*, 114*Vigna**V. sinensis*, 117*Yucca*, 106

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